CHAPTER 13

DATA CONVERSION DEVICES AND SWITCHBOARDS

INTRODUCTION

Data conversion is the process of modifying a signal into a form usable by the destination equipment. This conversion can be analog-to-digital (A/D), digital-to-analog (D/A), or digital-to-digital (D/D). An analog-to-digital converter is a device that converts a continuously variable input signal into a representative number sequence. A digital-to-analog converter (DAC) produces an analog signal proportional to the digital value. In digital-to-digital conversion, data is manipulated into a form usable by the destination equipment. This could consist of changing the logic levels of the signal or shifting data.

Switchboards are used to interconnect various combat direction systems' equipments with each other and with other shipboard systems.

After completing this chapter, you should be able to:

- **Define digital-to-analog and analog-to-digital conversion**

- **Define sampling, quantization, encoding, Gray code, and binary-coded decimal (BCD) as these terms apply to data conversion**

- **Describe the operation of synchro systems**

- **Describe the operation of a multiplexing data converter**

- **Describe the operation of manual and remotely controlled digital and analog switchboards**

TOPIC 1—FUNDAMENTALS OF DATA CONVERSION

Shipboard data conversion equipment handles a variety of types of data when communicating with other shipboard subsystems and equipment. In a number of instances, digital equipment must communicate with one or more analog or digital devices. A variety of equipment is installed throughout the fleet. Data conversion equipments encompass a large number of multifunction (MULTIPLEXED) and single function devices.

In general terms data conversion falls into three main categories: **analog-to-digital conversion,** **digital-to-analog conversion,** and **digital-to-digital conversion.** Within each of these categories, there are several different types of conversions, each unique in its own way.

ANALOG-TO-DIGITAL (A/D) AND DIGITAL-TO-ANALOG (D/A) CONVERSIONS

An analog signal is a signal that varies continuously with time. Its amplitude or other variables such as frequency or phase represent a value within a given set of limits. For instance, different values may be expressed or transmitted by changing the amplitude of

the signal. Digital quantities on the other hand are represented by binary numbers (ONES and ZEROS). The binary ONES and ZEROS indicate the value at a particular instant in time. Each bit position represents a portion of the overall quantity. The summation of the value of the set bits (ONES) is normally the quantity to be represented. By setting or clearing particular bit positions in the binary word, different values within a set of limits maybe expressed.
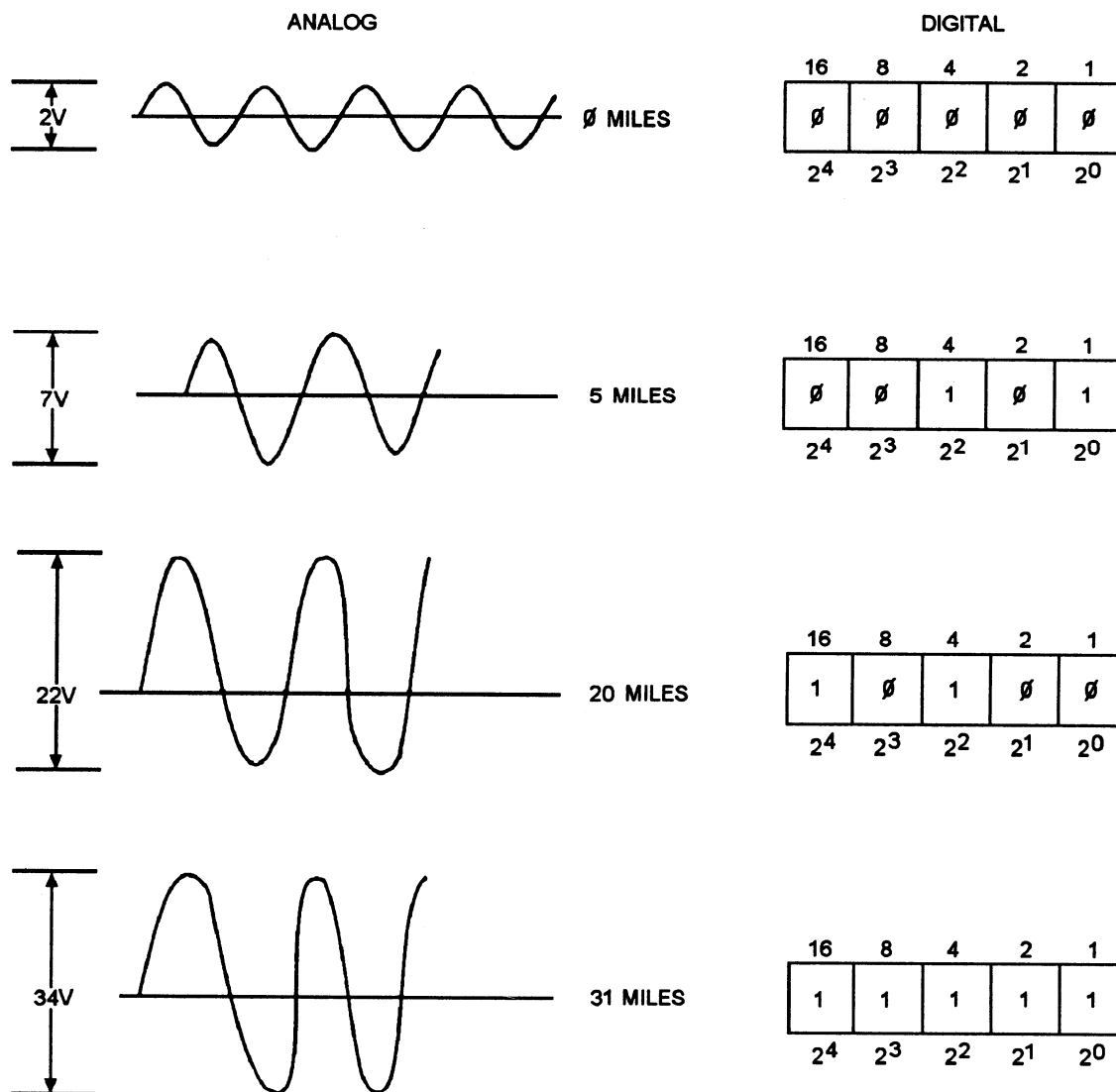
ANALOG AND DIGITAL QUANTITY COMPARISONS

Let's compare an analog quantity and a digital quantity representing the same **range of values,** say from 1 to 31 miles. The analog signal will be a **linear** single-phase ac sine wave. The ac signal is variable between 2 volts and 34 volts peak to peak. An amplitude of 2 volts peak to peak will indicate 0 miles, the **minimum limit** value, and an amplitude of 34 volts will indicate a value of 31 miles, the **maximum limit.** In this example, the increasing signal amplitude indicates an increase in range in miles.

The digital value will be expressed by five binary bits. Each bit position when set (a binary ONE) indicates a portion of the quantity. Bit 2^0 indicates a value of 1 mile, bit 2^1 a value of 2 miles, bit 2^2 a value of 4 miles, bit 2^3 a value of 8 miles, and bit 2^4 a value of 16 miles. Zero miles is indicated when all bits are clear (binary ZEROs). The maximum of 31 miles is indicated when all bits are set (binary ONES), 31 miles being the sum of the value of all the set bits ($1+2+4+8+16=31$).

Figure 13-1 shows the analog and digital representations of the same quantity through the range

Figure 13-1.—Analog and digital quantity comparisons.

13-2

of the values. At 0 miles, the analog signal is 2 volts peak to peak and the digital value is all ZEROS. For an indication of 5 miles, the analog signal increases to 7 volts peak to peak and the digital value now has bits 2^0 and 2^2 set. At 20 miles, the ac signal has increased to 22 volts peak to peak and bits 2^2 and 2^4 are set in the digital value. Finally when the maximum value is reached, the ac signal is 34 volts peak to peak and the digital value has all its bits set.

You should be aware that the values we have covered are extremely limited compared to the capabilities of most analog and digital devices. Much greater accuracy and ranges are commonly encountered; however, the basic fundamentals you have just learned will apply.

THE ANALOG-TO-DIGITAL CONVERTER

An analog-to-digital converter is a device or component of a larger device that receives an analog signal and converts it into a digital quantity with a given accuracy and resolution. The analog signal input is compared to a given **reference signal,** and the difference between signals is used to compute the digital quantity indicated by the analog signal. The reference signal is normally equivalent to the maximum value of transmitted data.

The basic analog-to-digital conversion process can be divided into a series of operations. Each operation performs a specific task in the conversion process. The analog-to-digital conversion operations are **sampling, quantization,** and **encoding.**

Sampling

Sampling is the first operation that takes place in an analog-to-digital conversion. Basically, the inputted analog signal is sampled or tested repeatedly over a period of time. This is done to determine the characteristic that contains the analog quantity, such as the signal's amplitude. A constantly varying input must be sampled at a much higher frequency than its own to ensure the accuracy of the conversion. Figure 13-2 shows a pulsed sampling of an ac signal. For each sample taken, a voltage level is determined. By comparing the voltages detected by the sample pulses, the largest voltage would tend to indicate the peak and hence the amplitude of the input signal. A sampling is performed on an analog signal only when a conversion is required.

Quantization

Quantization takes the sampled analog value and converts it to the nearest binary value or quantity. The accuracy of a binary quantity is limited to the value of the least significant bit (2^0). In the example in figure 13-1, bit 2^0 was the 1 mile bit, meaning the smallest value that could be indicated was 1 mile and the greatest accuracy was plus or minus 1 mile. Smaller values of 1/2 or 1/4 miles or less could not be indicated. Quantization, in effect, **rounds out** the conversion to the value of the least significant bit (LSB).

Encoding

The encoding operation reduces the result of the conversion to a binary code acceptable to the digital equipments that use the data. There is a variety of coding systems in use. You have already been introduced to one of the most common ones, **natural binary code.** This binary code expresses quantities as a weighted sum. Each bit position represents a specified value when set. The sum of the values of the set bits defines the value of the quantity. The bit with
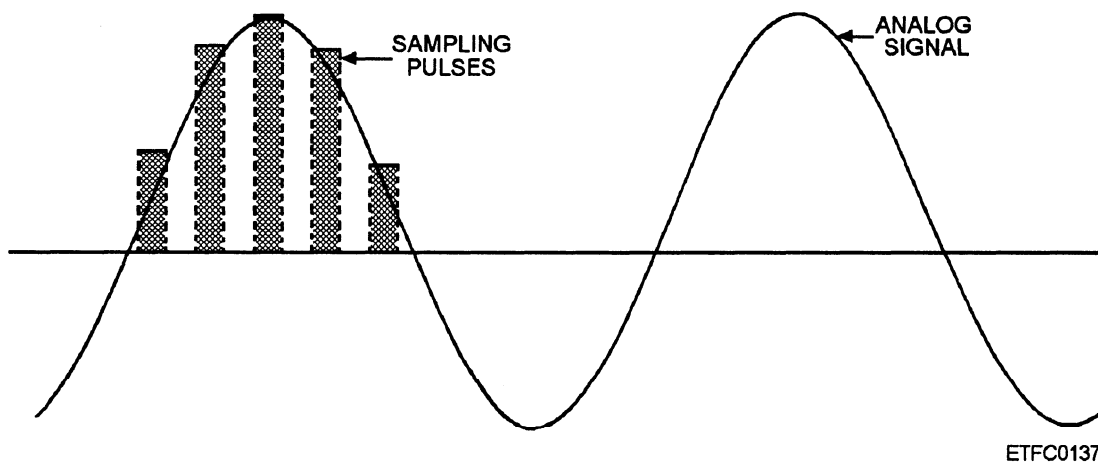

Figure 13-2.—Sampling pulses.

the greatest weight is the most significant bit (MSB). The bit with the least weight or representing the smallest value is the least significant bit (LSB). Natural binary code is used in a system of digital data transmission and conversion called **binary angular measurement** (BAM). Other coding systems such as **Gray code** and **binary-coded decimal** (BCD) are also used by analog-to-digital converters.

BINARY ANGULAR MEASUREMENT.— Binary angular measurement words (BAMs) are standardized binary words used to transfer angular measurements between shipboard tactical data system equipments. BAM data words are used to transfer quantities between digital equipments, from digital equipments to D/A converters, or from A/D converters to digital equipments.

BAM data words are specifically designed to indicate up to 360 degrees of angular values in binary form, often in **steps** or **increments** of as small as 0.009766 degree (the LSB value). Figure 13-3 shows one example of a BAM word. This 12-bit word (2^0-2^{11}) can indicate 360 degrees of angle in steps of 0.088 degree. The LSB is equal to 0.088 degree when set (ONE), while the MSB is equal to 180 degrees when set. When all 12 bits are set, a maximum angle of 359.902 degrees is indicated. ZERO or 360 degrees is indicated when all bits in the BAM data word are clear (ZEROS).

BAM words are also used to transmit non-angular values such as **range** or **height.** When non-angular values are being used, the LSB value indicates the smallest step or increment of the quantity being transmitted. The MSB value represents half the maximum value that may be transmitted. The sum of all bits when set indicates the maximum quantity that can be transmitted. This corresponds to the 0- to

360-degree capability of common shipboard synchro systems.

GRAY CODE.— Gray code or reflected binary code is used in devices where a transition from one consecutive value to another takes place, such as angular measurement and encoding. The code is designed to change from one value to the next with only one bit change. Table 13-1 shows the relationships between Gray code, BCD, and natural binary code.

BINARY-CODED DECIMAL (BCD).— BCD represents decimal values with a 4-bit code, called the 8-4-2-1 code. Each of the 4-bit groupings represents one decimal digit. BCD encoders allow for immediate decimal display of the converter output. They are found in such devices as digital voltmeters and other types of decimal display devices. Table 13-1 shows the relationships between BCD, Gray rode, and natural binary code.

SYNCHROS

Up to this point, we have discussed basically single-phase analog data signals. One of the most common shipboard analog signals requiring conversion is the 3-phase or 5-wire synchro signal. Synchros are used throughout naval ships for the rapid transmission of analog information between equipments and stations. They are found in just about every weapon, communication, underwater detection, and navigation system in use in the Navy. Numerous kinds of information involving **angular displacement** or **ranges of values** are transmitted. For the combat direction system (CDS) equipments to use this information, the synchro signals must be converted to their digital equivalent. The following information provides a limited overview of synchros as they apply to digital systems and synchro-to-digital (S/D) conversion.
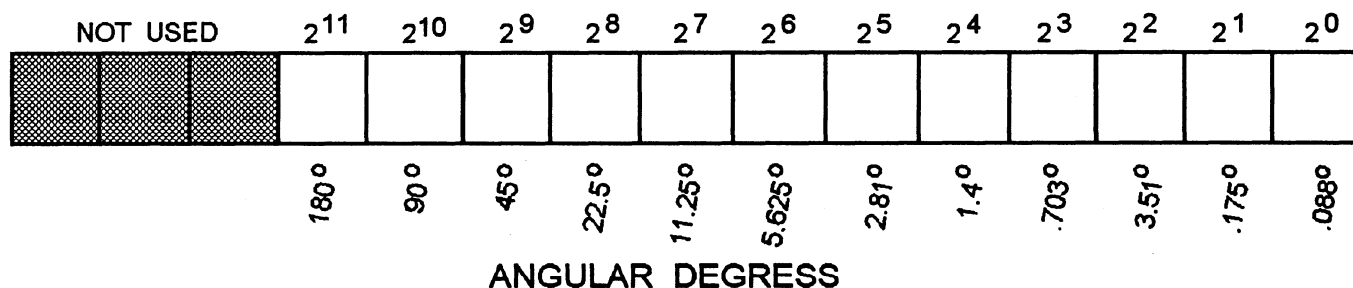
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Figure 13-3.—A 12-bit binary angular measurement (BAM) word.

Table 13-1.—Comparison of Binary-Coded Decimal (BCD), Gray Code, and Natural Binary Code

DECIMAL	BCD	GRAY CODE	NATURAL BINARY CODE
0	0000 0000	0000	0000
1	0000 0001	0001	0001
2	0000 0010	0011	0010
3	0000 0011	0010	0011
4	0000 0100	0110	0100
5	0000 0101	0111	0101
6	0000 0110	0101	0110
7	0000 0111	0100	0111
8	0000 1000	1100	1000
9	0000 1001	1101	1001
10	0001 0000	1111	1010
11	0001 0001	1110	1011
12	0001 0010	1010	1100
13	0001 0011	1011	1101
14	0001 0100	1001	1110
15	0001 0101	1000	1111

Synchro Systems

The term *synchro* is an abbreviation of the word *synchronous.* It is the name given to a variety of rotary, electromechanical, position sensing devices. Synchro signals are used to transmit the **angular position** (0 to 360 degrees) of a rotor shaft in a **synchro transmitter.** When the signals are applied to one or more synchro **receivers,** the rotor shaft-in each receiver is positioned to match the transmitter's shaft position (figure 13-4). In this example, the receiver shaft in turn drives an indicator dial to display the transmitted information.

The combination of synchro transmitter and receivers is called a **synchro system.** There are two major classifications of synchro systems: torque systems and control systems.
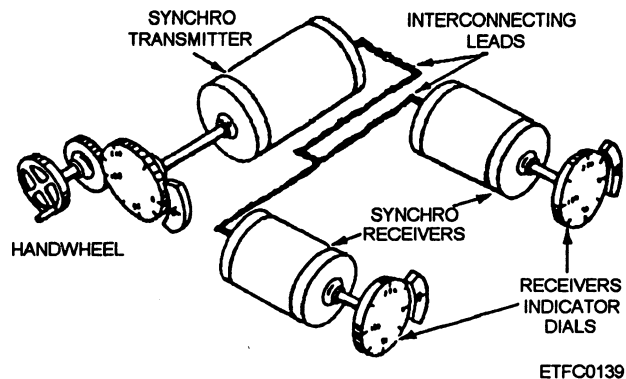

Figure 13-4.—Torque synchro system transmitter and receivers.

Torque systems provide torque or turning force to drive light loads such as indicator dials, pointers, or other mechanical outputs.

Control synchro systems provide an electrical output used to control the power that performs mechanical work. The control synchro normally feeds a control transformer, not a control receiver. The control transformer output is fed to devices such as a servo system to control larger systems and devices.

The synchro signals converted by CDS equipment may be either control synchro signals or torque synchro signals; however, control synchro signals are preferred because they are generally more accurate than torque synchro signals.

OPERATING VOLTAGES AND FREQUENCIES.— Most shipboard synchro systems operate on a supply voltage of 115 volts ac at a frequency of 60 or 400 Hz. Synchros operating at 115 volts 400 Hz are generally more accurate than the 60-Hz synchros. Most newer weapon systems use 400-Hz synchros exclusively.

SINGLE-SPEED, MULTISPEED, AND DUAL-SPEED SYNCHRO SYSTEMS.— The accuracy of the data to be transmitted is a factor in any synchro system. If the data covers a wide range of values, then the basic synchro system is unable to detect small changes in the data. When this happens, the accuracy of the system decreases. Multispeed synchro systems were developed to correct this deficiency.

Multispeed synchro systems use more than one speed of data transmission. The speed of data transmission is the number of times the synchro transmitter rotor must turn 360 degrees to transmit a full range of values. In a 1-speed system, one rotation of the transmitter rotor covers the full range of values. The

rotor is geared to its mechanical input and one rotation of the input results in one revolution of the transmitter's rotor. The speed of a synchro transmitter is tied to the gear ratio between the mechanical input to the transmitter and the transmitter's rotor; that is, 1:1, 36:1, and so on.

In a 36-speed synchro system, the rotor of the synchro transmitter is geared to rotate 36 times for one revolution of the input shaft (36:1). Units transmitting data at one speed (l-speed, 36-speed, and so forth) are called **single-speed synchros.** The entire range of data to be transmitted is contained in the output of the single-synchro transmitter.

It is quite common for shipboard synchro systems to transmit data using two different speed synchros with the same reference or supply voltage. For example, ship's course (ownship's heading) information is usually transmitted to other locations using a 1-speed synchro and a 36-speed synchro. A synchro system that transmits data using two different speed synchros is called a **dual-speed synchro system** or a double-speed synchro system.

COARSE AND FINE DATA TRANSMISSION.— Dual-speed synchro transmissions are combined to improve the accuracy of the data transmitted. The use of two transmitting synchros allows for a **coarse** value and a **fine** value to be sent at the same time. The synchro with the lowest ratio (1:1) sends the coarse value. The synchro with the highest ratio (36: 1) sends the fine value. The coarse and fine values transmitted can be likened to the hour and minute hands of a clock. The course value represents the time in hours. The fine value represents the time in minutes. The two values must be combined to give the time in hours and minutes.

Let's look at a coarse synchro and a fine synchro transmitting an angular position such as ship's course (ownship's heading), which can be from 0 degrees to 359 degrees true. The coarse synchro (1:1) indicates 360 degrees of ship's course with one rotation. However, the accuracy of the data is limited to plus or minus 1 degree of heading. This degree of accuracy is not enough for most navigation systems to keep an accurate track of ship's movement. The fine synchro (36:1) rotates 36 times for each rotation of the coarse synchro. This means the fine synchro rotates once each 10 degrees (360/36). Within its 10-degree segment, the fine synchro is 36 times as accurate as the coarse synchro. The use of dual-speed synchros requires two S/D conversions to take place; one to determine the position of the rotor in the coarse synchro transmitter

and one to determine the position of the rotor in the fine synchro transmitter.

SYNCHRO SIGNALS.— A single-speed synchro transmitter outputs three waveforms that indicate the angular position of the rotor in the transmitting synchro, for example a control transmitter (CX). Waveforms are induced in the stator coils by the magnetic field of the rotor coil. The two rotor connections of the CX (R1 and R2) are fed from a 115-volt ac supply voltage (also called the **reference voltage).** This voltage is also fed to the synchro-to-digital (S/D) converter circuitry. The reference voltage is important in the conversion process. It provides a reference for the S/D converter to use when sampling the stator voltages.

The amplitude of the voltage output between the stators (S1 to S2, S1 to S3, and S2 to S3) at any instant is dependent on the position of the rotor in the CX. The 115-volt supply voltage induces an ac voltage into the stator windings. The phase relationship of the signals induced on each stator winding is dependent on the angular position of the rotor within the CX. The rotor can normally be rotated 360 degrees within the synchro. The range of values being transmitted is tied to this 360 degree rotation.   The minimum value is normally transmitted with the rotor at the 0-degree position and the maximum value is sent when the rotor is positioned to approximately 359 degrees.

All three stator signals are ac voltages that have the same characteristics (frequency and amplitude). They have a 120-degree phase difference (phase displacement) from each other due to the 120-degree separation of the wye windings of the stator coils in the synchro transmitter. At any instant, a phase relationship exists between the rotor supply (excitation) voltage and the three stator voltages. This phase relationship is the key to the S/D conversion process.

Basically, the phase relationship of the individual stator voltages, across terminals S1, S2, and S3, varies with the rotor supply voltage (R1-R2) as the rotor is rotated within the synchro transmitter. Each position of the rotor has a unique stator voltage phase relationship to the supply (reference) voltage. At any instant, the amplitude and polarity of the stator signals when compared to the supply voltage indicate the angular position of the rotor.

For dual-speed synchro systems, two sets of stator voltages are transmitted, one set for the coarse synchro and one set for the fine synchro. A single supply voltage (reference) is used for both synchro

transmissions. In other words, both speeds are converted using the same reference signal.

Synchro-to-Digital (S/D) Conversion

Two methods are currently in use to convert synchro data to digital words (BAMs): the **sector** method and the **octant** method. Both methods of conversion require a reference voltage input for conversion to take place.

SECTOR CONVERSION.— The sector conversion method uses the reference voltage to determine the time to sample the stator voltages for conversion to take place. The ideal time to sample the stator voltages is when the reference voltage is at or near the positive or the negative peak of its cycle.

Sixty-Degree Sector Determination.— Once the negative or the positive peak of the reference is detected, the sector in which the rotor is positioned may be determined. There are six 60-degree sectors within the 360-degree rotation of the rotor. The relationship of the stator voltages to the reference defines the sector. Table 13-2 shows the sector limits and the phase relationship of the stator voltages to the reference in each sector.

Stator Voltage Selection.— When the sector angle is determined, two of the three stator voltages are used to identify the ratio angle within the sector. The ratio angle is determined by a ratio between the two voltage samples. The two stator voltages selected depend on the sector. The appropriate voltages are gated to the conversion circuitry and converted to binary data. The sector angle and the ratio angle of the two stator voltages are summed to determine the binary angle of the rotor position in BAMs.

Table 13-2.—Phase Relationship of Stator Voltages to Reference

SECTOR	S1	S2	S3
330-30	IN	OUT	IN
30-90	IN	OUT	OUT
90-150	IN	IN	OUT
150-210	OUT	IN	OUT
210-270	OUT	IN	IN
270-330	OUT	OUT	IN

OCTANT CONVERSION.— The octant conversion method divides the 360 degrees of angular measurement into eight 45-degree octants. The conversion process first defines the octant and then the binary representation of the trigonometric angle within the octant.

Octant Determination.— The 5-wire synchro signal (R1, R2, S1, S2, and S3) is first converted into two dc voltages representing the sine and cosine of the synchro angle. The polarity of the sine and cosine voltages and their respective amplitude to each other are used to select the octant that defines the three most significant bits of the BAM word (figure 13-3).

Successive Approximations.— The remaining bits of the BAM word are determined through a process of successive approximations. The sine and cosine voltages are combined into a ratio voltage that is used to determine the condition of each of the remaining bit positions in the BAM word, starting at the MSB of the remaining bits. A trial and error method is used. A trial binary angle is generated and tested against the ratio angle until the trial angle equals the ratio angle, completing the conversion process.

Single-Speed/Dual-Speed Synchro Conversions

Synchro-to-digital conversions do not occur on a continuous basis. The synchro data is sampled as required by the controlling computer, usually on a periodic basis. A single BAM word is generated by the S/D conversion for both single- and dual-speed synchros. When dual-speed synchro data is being converted, two S/D conversions are required to generate one BAM word. The coarse synchro signal is converted immediatey before the fine synchro signal. The summation of the two conversions is represented by a single binary word, indicating one angular value. Conversions for single-speed synchros are considered coarse conversions only.

NOTE.— For more detailed information on synchros and synchro systems, refer to NAVEDTRA 172-15-00-80, NEETS, Module 15, *Principles of Synchros, Servos, and Gyros.*

DIGITAL-TO-ANALOG CONVERSION

Digital-to-analog (D/A) conversion is required when digital devices must communicate with an analog system or equipment. Three types of D/A conversion are commonly encountered on shipboard systems: **digital-to-linear, digital-to-scalar,** and **digital-to-synchro (D/S).** Linear signals are ac or dc voltages that

normally represent a quantity based on their amplitude with respect to a reference voltage. Scalar signals consist of two waveforms that represent the sine and cosine of an angle. The device that performs these types of conversions is a digital-to-analog converter (DAC). The DAC may be either a component of a larger device or a stand-alone equipment such as the Digital-to-Analog Converter CV-2517B/UYK.

Digital-to-synchro conversion is required when communicating with systems that use synchro data transmission. Digital-to-synchro converters are usually found as components of multipurpose conversion equipment. However, a DAC may be modified with a scott-tee transformer to generate synchro signal outputs from scalar voltage waveforms.

DIGITAL-TO-LINEAR/SCALAR CONVERSION

A digital-to-analog converter (DAC) is a device that receives digital information in the form of a binary word and transforms that information into variations of an analog signal. The DAC outputs an analog signal derived from a reference signal. Normally both the converter and the analog device receiving the data operate off of the same reference. The reference signal is normally greater than or equal to the maximum limit of the output of the converter.

The continuous output signal is varied in **steps** based on the binary inputs to the converter. BAMs are normally used as the binary input for CDS DACs. As a bit position changes in the binary data, the output signal is stepped up or down, based on the value of the bit position or bit positions changed in the input. The output signal only changes when the input data changes.

Each converter outputs a single proportional voltage signal. This signal is suitable for linear operations. Two converters are required for scalar or synchro conversions. Two separate proportional voltages must be developed to represent the scalar sine/cosine angle which may in turn be fed to a scott-tee transformer to generate a 3-wire synchro signal.

THE DIGITAL-TO-ANALOG CONVERTER CV-2517B/UYK

The Digital-to-Analog Converter (DAC) CV-2517B/UYK is a multipurpose converter capable of accepting parallel digital data and converting it to 400-HZ linear, resolver, or synchro outputs. The DAC (figure 13-5) provides the means for digital combat direction systems to communicate with analog gun, electronic countermeasures (ECM), or sonar subsystems.
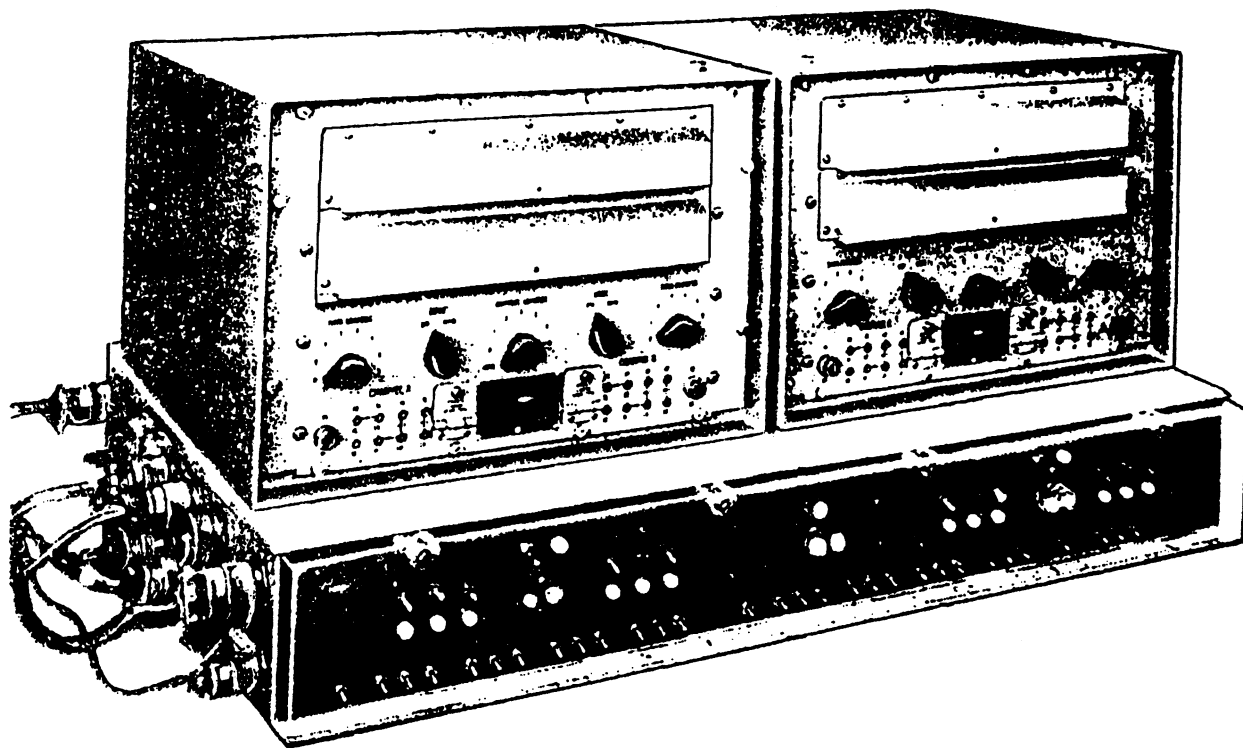

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Figure 13-5.—DACs and mounting base.

The DAC is mounted on an Electronic Equipment Mounting Base MT-3574B/USQ-20(V), referred to as a BASE. The BASE can accommodate two DACs, as shown in figure 13-5. It provides all electrical interfaces, selects DAC operating modes (TRIGONOMETRIC or LINEAR), and provides simulated digital data for test purposes.

There is an accessory to the DAC called the Analog-to-Analog Converter (AAC) CV-2518/UYK. The AAC provides signal conversion from linear ac to linear dc or linear dc to linear ac.

Each DAC is divided into two identical channels, designated channels A and B. Each channel can output two linear voltages, a sine/cosine resolver (scalar), or a single-speed synchro, depending on the operational mode selected. For simplicity, only one base with one channel of a DAC connected in the converter 1 position is covered here. The base and converter operate as one unit and are discussed as one.

The DAC normally receives computer output from a 30-bit parallel keyset central multiplexer (KCMX)

digital output channel (DOC). Both the KCMX and DOC functions are covered in this chapter. The output passes through the mounting base, which is transparent for normal computer operations. The output buffer consists of an external function (EF) word, a control address word, and up to eight data words. The EF word master clears the DAC and initiates the receive data from unit computer (RDUC) operations. The control address word defines the control address of the DAC to receive the data words. The individual DAC's control address is set using the eight-position CONTROL ADDRESS switch on the DAC front panel (figure 13-6). If the data is properly addressed to the DAC, the DAC initiates RDUC operations to process the data words coming from the computer.

Each data word contains a data address code (0-7) to define the DAC channel (A or B) that is to process the data. Both DAC channels receive the data; however, only the channel with the CHANNEL DATA ADDRESS switch in the position to match the data address will process the data.
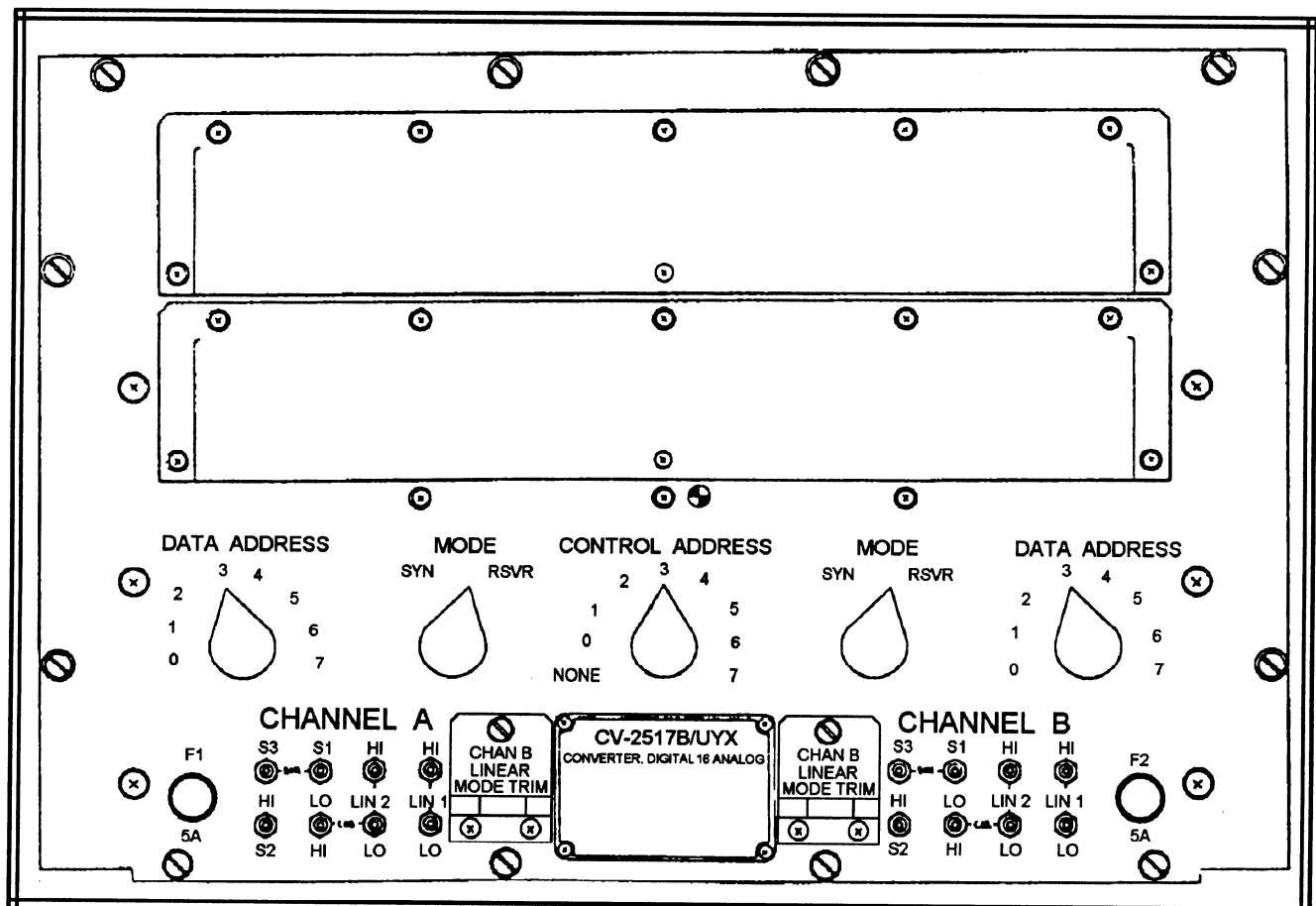
Figure 13-6.—DAC front panel.

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DAC Functional Description

The DAC can be divided into three major sections: the digital section, the analog section, and the power supply section, as shown in figure 13-7.

DIGITAL SECTION.— The digital section processes the EF word and the control address word upon receipt of the EF signal from the computer. If the control address matches the channel A or B address, the digital section generates the output data request (ODR) signal to the computer to start the data word processing. The computer provides a data word along with the output acknowledge (OA) signal. The converter then drops the ODR indicating it has accepted the data. The data bits are fed to the digital section holding registers for the applicable channel and subchannels. The output of the holding registers is fed to the analog section for conversion to proportional voltages.

ANALOG SECTION.— The primary function of the analog section is to convert the data words received from the digital section into proportional analog voltages. The form of the analog output is dependent on the mode of operation (TRIG or LINEAR) and, during the TRIG mode, the type of output selected (synchro or resolver). The switches for selecting the converter mode (TRIG/LINEAR) are located on the base (figure 13-8). The switches for selecting synchro or resolver operation in the TRIG mode are located on the DAC front panel (figure 13-6).

Each DAC channel (A or B) is in turn divided into two subchannels (A1 and A2 or B1 and B2). The data words accepted by the DAC channel are made up of two 13-bit data words consisting of a polarity bit and a 12-bit code. In the TRIG mode, the 12-bit code represents the sine or cosine outputs. In the LINEAR mode, the 12 bits are converted directly to linear voltages. Channel Al outputs the sine waveform in the TRIG mode or one of the linear waveforms in LINEAR mode. Channel A2 outputs the cosine waveform in the TRIG mode and the second linear waveform in the LINEAR mode. The polarity bits are used to determine the quadrant in which the angle lies in the TRIG mode and the polarity of the linear output in the LINEAR mode.

The actual digital-to-analog conversion is performed using two resistive ladder networks (one each for channels A1 and A2). The logic state of the data and polarity bits controls the operation of analog switches, which route currents from a ladder network into a summing network. A reference voltage for the ladder network is supplied from selected reference transformers. The selection of the reference transformers is dependent on the mode of operation and the state of the applicable polarity bit in the data word. When the proper reference voltages are selected, the currents through the ladder network are summed and applied to the output selection circuit as proportional voltages.

The channel A1 and channel A2 proportional voltages represent the sine and cosine voltages for resolver output. For synchro output, the sine and cosine voltages are fed to a Scott-tee transformer by the output selection circuitry. The Scott-tee output consists of the 3-wire, single-speed synchro output.
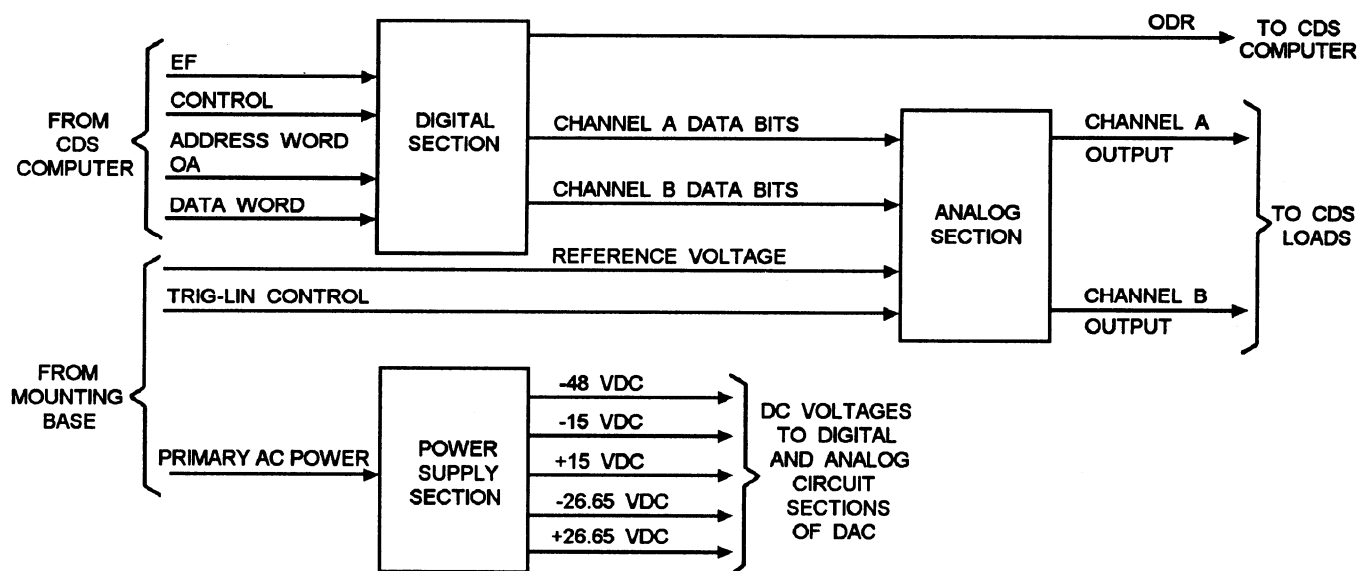
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Figure 13-7.—DAC block diagram.
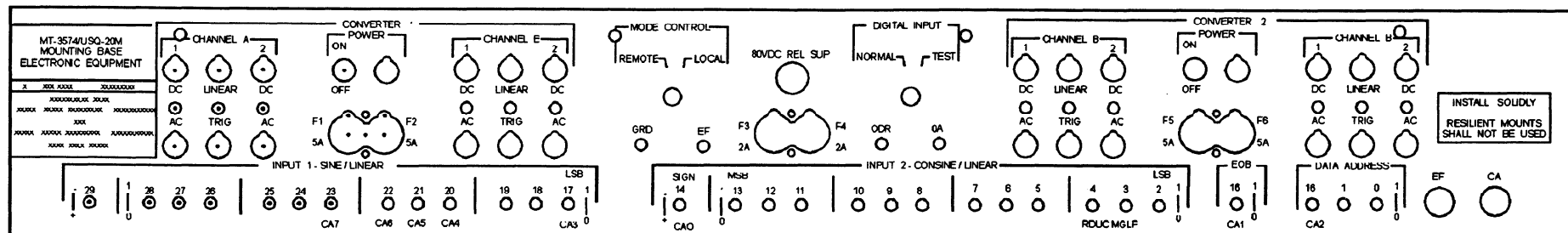
Figure 13-8.—Mounting base.

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POWER SUPPLY SECTION.— The power supply section provides five regulated dc voltages (-4.8, -15, +15, -26.65, and +26.65 vdc) that support the operation of the digital and analog sections of the DAC. The power supply section receives primary ac power from the mounting base.

Base Controls and Indicators

The mounting base (figure 13-8) provides controls and indicators for the operation of the mounting base and the two associated converters (CONVERTER 1 and CONVERTER 2).

MODE CONTROL LOCAL/REMOTE.— This rotary switch selects either REMOTE control of converter operating modes or LOCAL control via the BASE switches.

DIGITAL INPUT NORMAL/TEST.— This rotary switch selects either NORMAL digital inputs from the computer or TEST digital inputs simulated by switches on the BASE.

OA/EF.— The OA (output acknowledge) and EF (external function) pushbuttons are used to simulate their respective control signals to the converters in TEST mode.

CONVERTER 1 POWER ON/OFF.— This switch applies ac power to converter 1 and the right half of the BASE indicator lights. (Because both converter switches and indicators are identical, we will only cover converter 1.)

CONVERTER 1 CHANNEL A.— This group of switches and indicators is used to select and monitor the channel mode (TRIG/LINEAR toggle switch) and the subchannel linear voltage type (CHANNEL A1 AC/DC and CHANNEL A2 AC/DC toggle switches) when the

BASE is in LOCAL or REMOTE. (Because both channel A and channel B switches and indicators are identical, we only cover channel A.)

THIRTY TOGGLE SWITCHES.— A row of 30 toggle switches is used to simulate EF and data word binary data bits when in the TEST mode.

DAC Controls and Indicators

The DAC provides controls for addressing channels A and B, selecting the TRIG mode (synchro or resolver), and test points for verifying individual channel functions.

CHANNEL A MODE SYN/RSVR.— When the TRIG mode is selected at the BASE, this switch selects synchro or resolver output.

CHANNEL A DATA ADDRESS.— This 7-position switch is used to select the address for channel A. (Because both channel A and channel B controls are identical, we only cover channel A.)

Digital-to-Synchro (D/S) Conversion

A digital-to-synchro (D/S) converter converts BAM data words to single-speed synchro output signals. The D/S converter requires a reference voltage input (115 volt, 60/400 Hz). The D/S conversion is effectively a reverse of the S/D conversion process.

The BAM word is used to generate two analog voltages representing the sine and cosine of the synchro rotor angle to be transmitted (figure 13-9). These two voltages are developed by modulating the stepped down reference voltage in phase and amplitude. The phase relationship and amplitude of the sine and cosine signals are based on the data contained in the BAM word. The sine and cosine signals are then stepped up and fed to a
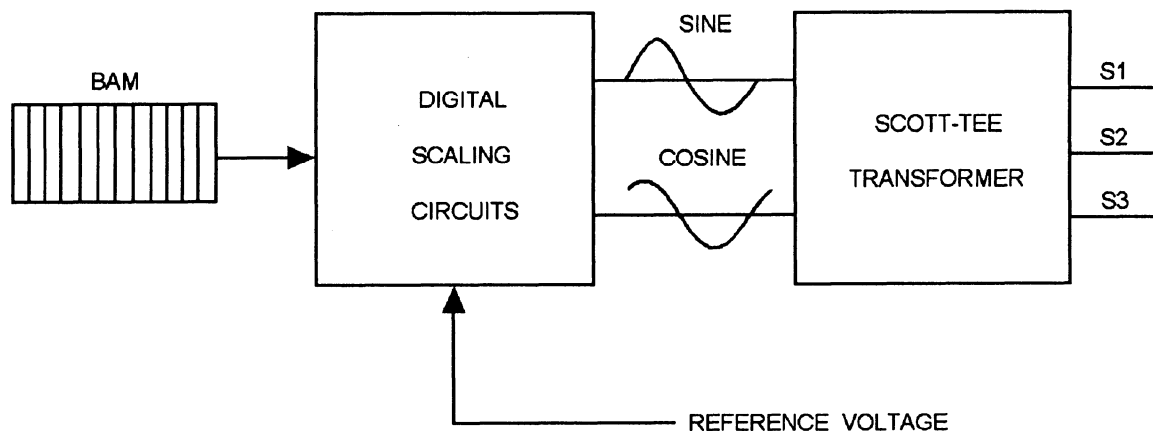
Figure 13-9.—Digital-to-synchro (D/S) conversion.

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scott-tee transformer to develop the 3-phase stator voltage outputs (S1, S2, and S3) of the single-speed synchro transmission.

D/S converters are designed with holding circuits that retain the contents of the BAM words between computer updates of BAM data. The synchro output of the D/S converter is continuous in nature, indicating a new rotor angle only when a BAM word received from the controlling computer contains anew angular value.

DIGITAL-TO-DIGITAL (D/D) CONVERSION

This section covers those forms of digital data handled by various shipboard data conversion devices. These devices are used to convert digital data from shipboard weapon, radar, and other subsystems to the voltage levels and formats acceptable to the CDS computers.

The types of data converted include control and status signals, ready digital (RD) data, demand digital (DD) data, demand digital interrupt (DDI) data, and digital input channel/digital output channel (DIC/DOC) data.

Control and Status Signals

Control and status signals are discrete ac or dc signals that indicate or control a single function (on/off, true/false, and so forth) or condition in a subsystem. Signals transmitted by CDS equipment to another subsystem are referred to as **control signals** because they generally initiate an action in the receiving system. Discrete signals received by CDS equipment are referred to as **status signals** because they generally indicate the status of a condition or function in another subsystem.

CONTROL SIGNALS.— Control signals are generated from individual bit positions in a control word. Each bit position of the control word represents one control signal. The individual bits from the control word are fed to relay circuits. A binary ONE will cause a relay closure to take place and an ac or dc signal to be generated from the appropriate supply voltage. A binary ZERO will cause the relay to de-energize, open its contacts, and prevent the voltage transmission.

STATUS SIGNALS.— Status signals are ac or dc voltages received from external subsystems. Each status signal is assigned to an individual bit position in a status word. The status bit becomes a binary ONE when a status voltage is sensed. Lack of a status voltage signal causes the status bit to remain a binary ZERO. Status words are sampled periodically by the controlling computer to determine the current condition of the individual status signal bits.

Ready Digital (RD) Data

Ready digital (RD) data is 12-bit parallel digital data generated by the CDS radar azimuth converters (RACs). The data indicates the antenna or sweep position of each individual ship's radar. This data is transmitted to the CDS computer as requested by the computer for program processing and tracking of radar contacts.

Demand Digital (DD) Data

Demand digital (DD) data is parallel digital data input from manual entry devices. Two input channels are normally used. Each channel may be used by up to eight daisy-chained devices. Each device is identified by an address in the input word. DD data is sampled periodically by the computer to test for operator entries.

Demand Digital Interrupt (DDI) Data

Demand digital interrupt (DDI) data is parallel digital data similar to DD data. The major difference is in the method of data entry. DDI devices cause an interrupt to be generated to the controlling computer when an entry is made from the applicable device.

Digital Input Channel/Digital Output Channel (DIC/DOC) Data

Digital input channel/digital output channel (DIC/DOC) channels are multiplexed parallel digital computer channels used to increase the input/output capabilities of the controlling computer. Up to four DICs and four DOCs are provided. The channels may be used for input only, output only, or input/output (I/O) with external peripheral devices or computers depending on the mode or format selected.

TOPIC 2—SHIPBOARD DIGITAL/ANALOG SYSTEM INTERFACES

In this topic, you will learn about specific equipments and groupings of equipments involved in the data inversion and interfacing process aboard ship. These equipments permit nominally independent

shipboard systems or subsystems to communicate or interface with the combat direction system (CDS).

MULTIPLEXING DATA CONVERTERS

Each shipboard tactical data system has at least one multiplexing data converter. Multiplexing data converters are, in effect, computer-controlled multipurpose devices that operate between one or more digital computers and a number of control, status, digital, and analog devices located in remote subsystems. The individual devices may vary from each other in design due to technological advances and equipment improvements. As a group they perform multiple functions by allowing analog or digital conversion and communications with a variety of equipments or subsystems using multiple data forms (analog, discreet digital, or parallel digital) at the same time or within a very narrow time period (time division multiplexing).

Several different versions/generations of multiplexing data converters are currently in use. These include the Keyset Central Multiplexer (KCMXs) CV-2036/USQ-20 and CV-3263/USQ-20 and the Signal Data Converters (SDC) OU-95/UY, CV-2953A, and the Mark 72 Mod 11/12. Individual capabilities vary from device to device. Table 13-3 lists the various converters and compares the range of their capabilities. The particular converter used with the tactical data system depends primarily on ship class. KCMXs are found on the CG or DDG classes and the CV/CVN aircraft carriers. ICKCMXs are found on the DDG TDS

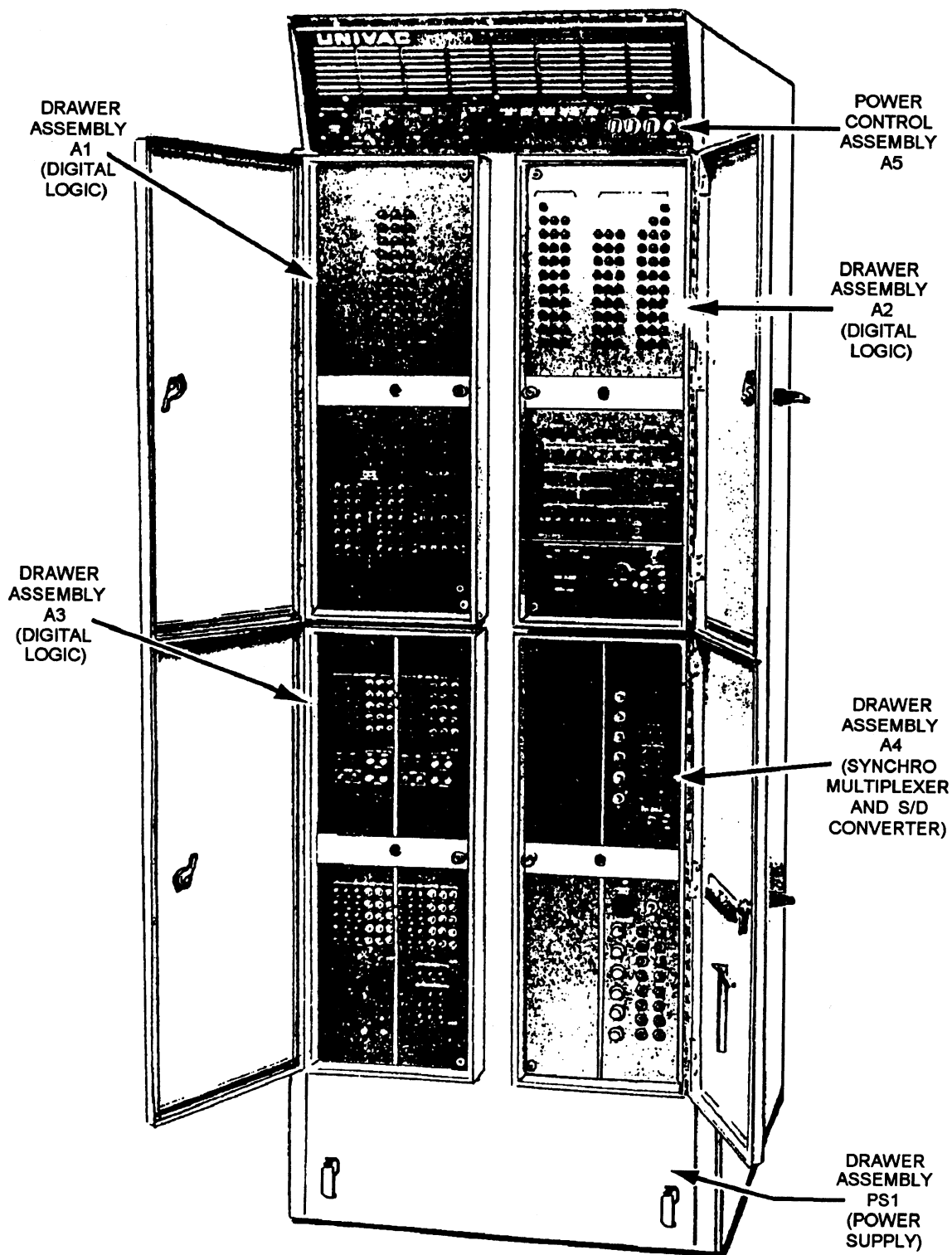Table 13-3.—Comparison of Multiplexing Data Converters

FUNCTION	CV-2036 (KCMX)	CV-3263 (KCMX)	OU-95 (ICKCMX)	CV-2953A (SDC)	MK 72 MOD 11/12 (SDC)
CONTROL SIGNALS	56	12	31	15	150
STATUS SIGNALS	60	60	32 (8 STATUS INTERRUPT SIGNALS)	15	90
READY DIGITAL DATA	8 INPUTS	4 INPUTS			
READY ANALOG DATA	32 INPUTS	32 INPUTS	8 INPUTS	9 INPUTS	19 INPUTS
DEMAND DIGITAL DATA	16 DEVICES	8 DEVICES	1 DEVICE	16 DEVICES	24 DEVICES
DEMAND DIGITAL INTERRUPT DATA	8 DEVICES			8 DEVICES	24 DEVICES
DIGITAL INPUT CHANNELS	4 CHANNELS	2 CHANNELS			
DIGITAL OUTPUT CHANNELS	4 CHANNELS	4 CHANNELS			3 CHANNELS
DIGITAL-TO-ANALOG DATA (SYNCHRO)			4 OUTPUTS	12 OUTPUTS	8 OUTPUTS
READY DIGITAL OUTPUT CHANNEL				1 CHANNEL (10 BITS)	
LINEAR-TO-DIGITAL DATA					26 INPUTS (ac or dc)
DIGITAL-TO-LINEAR DATA					69 OUTPUTS (ac or dc)

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systems, while the CV-2953A is found on the DD-963 class of ships. Mark 72 SDCs are found on the CGN-38 class of cruisers.

The KCMX handles the widest range of functions of any of the converters. For that reason we selected it as our representative training device.

KEYSET CENTRAL MULTIPLEXER (KCMX)

The keyset central multiplexer (KCMX) (figure 13-10) provides the means of exchanging data, control, and status information between either one of two

DRAWER ASSEMBLY A1 (DIGITAL LOGIC)

POWER CONTROL ASSEMBLY A5

DRAWER ASSEMBLY A2 (DIGITAL LOGIC)

DRAWER ASSEMBLY A3 (DIGITAL LOGIC)

DRAWER ASSEMBLY A4 (SYNCHRO MULTIPLEXER AND S/D CONVERTER)

DRAWER ASSEMBLY PS1 (POWER SUPPLY)

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Figure 13-10.—KCMX (front view).

computers and a variety of input/output devices including multiple control, status, and synchro signal interfaces. The KCMX allows the controlling computer to receive data and status information from external subsystems (missile, gun, electronic warfare [EW], antisubmarine warfare [ASW], and so forth) and to transmit data and control information to external subsystems. A simplified block diagram of the KCMX is shown in figure 13-11.

Duplexer and Input/Output (I/O) Logic

The duplexer (figure 13-11) allows the KCMX to be controlled by two computers on a one at a time basis. The duplexer is controlled by external function commands from the computers. Three external function commands are used to control the duplexer logic: request control, release local, and release remote.

REQUEST CONTROL.— The request control (RC) command permits the requesting computer to gain control of the KCMX if the other computer is not in control.

**RELEASE LOCAL.**— The release local command relinquishes control of the KCMX.

RELEASE REMOTE.— The release remote command is a high-priority code that allows one computer to take control of the KCMX from the other computer.

I/O LOGIC.— The KCMX communicates with the digital computers over standard CDS slow I/O channels.

Digital Control Logic

The digital control logic (figure 13-11) puts the KCMX in one of its seven operating modes as specified by the controlling computer. The KCMX operating modes are neutral, duplex, transmit data from unit computer (TDUC), receive data from unit computer (RDUC), TDUC and RDUC, interrupt, and keyset error.

NEUTRAL MODE.— Neutral mode is the at-rest mode when neither of the controlling computers is requesting control of, or is in control of, the KCMX.
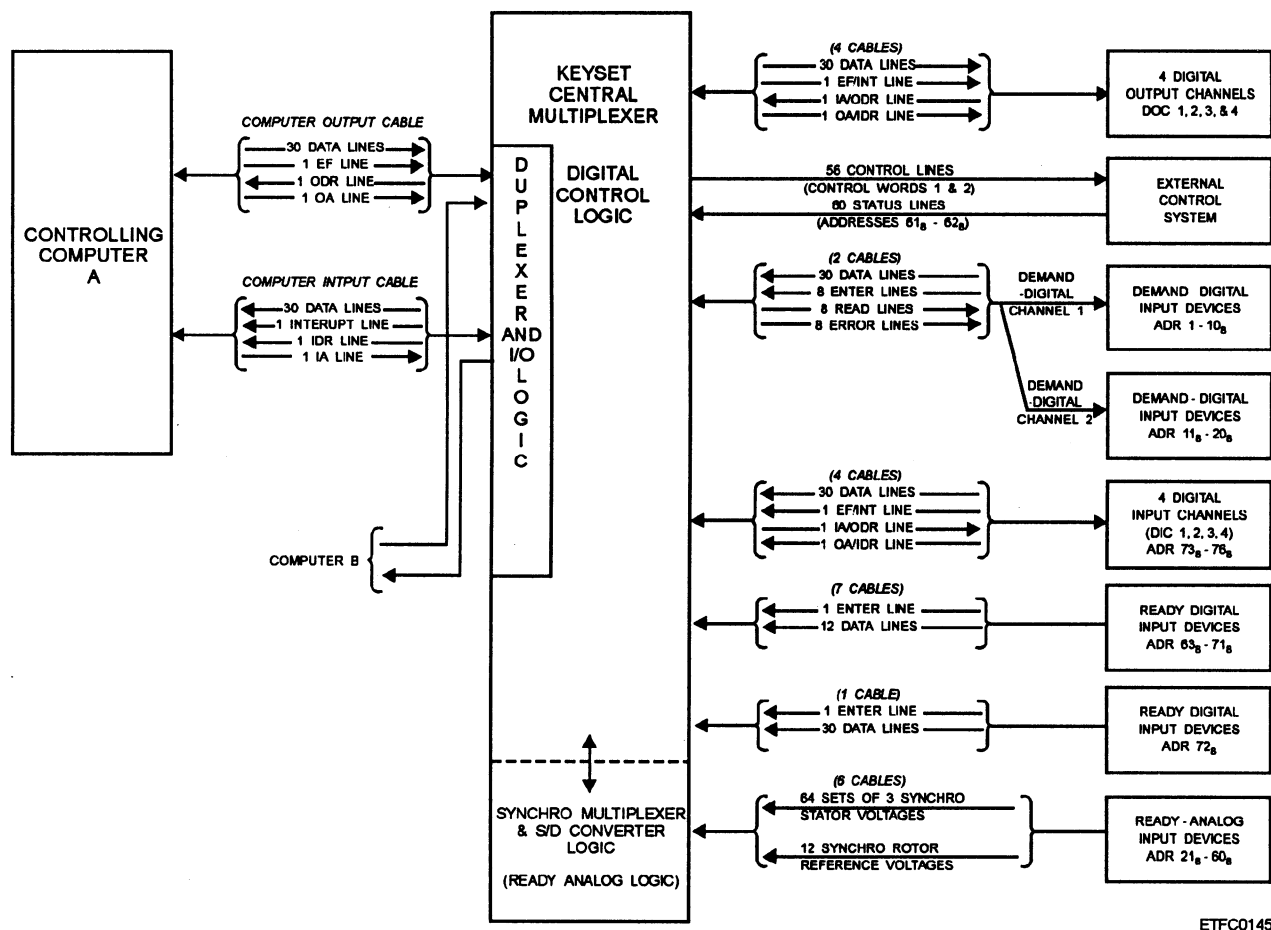
Figure 13-11.—KCMX block diagram.

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DUPLEX MODE.— The duplex mode is the primary control mode for the KCMX. Either of two computers may have control of the KCMX at one time. Each computer must request control by means of an external function. Once the desired mode selections and data exchanges have taken place, the controlling computer must place the KCMX in a neutral state through the use of a release local external function.

RECEIVE DATA FROM UNIT COMPUTER (RDUC) MODE.— To output data to the KCMX, the controlling computer must place the KCMX in the RDUC mode by external function. In the RDUC mode, the KCMX is capable of receiving data consisting of DOC output words or control words. DOC data and control signals are the only KCMX functions used to transmit information to external subsystems or equipment.

TRANSMIT DATA TO UNIT COMPUTER (TDUC) MODE.— The TDUC mode is used to input addressed data to the controlling computer. The computer places the KCMX in TDUC mode. The external function command specifies the address or addresses of the data to be transmitted to the computer.

TDUC AND RDUC MODE.— The KCMX can be placed in the TDUC and the RDUC modes at the same time. Both modes will operate simultaneously under the control of one computer.

INTERRUPT MODE.— The KCMX operates in the interrupt mode when indicating an abnormal condition (Type I interrupt) or upon receipt of high-priority data from DDI addresses or DIC external functions or interrupts (Type II interrupt).

KEYSET ERROR MODE.— The computer places the KCMX in the keyset error mode to send an error signal to the addressed keyset.

Demand Digital (DD) Inputs

The 16 demand digital (DD) inputs (figure 13-11) use 30-bit words. Eight DD devices are daisy chained on each of two cables. Each DD device (keyset) is controlled by three control signals: enter, read, and error. A total of 24 control signals is required for the eight DD devices on an input cable.

The eight DD devices on the first cable are called group 1 and are assigned KCMX addresses 1 through 10 (all KCMX addresses are octal). Group 2 consists of the other eight devices on the second cable and are referenced by KCMX addresses 11 through 20. Group 1 DD devices may function in either a data (DD) mode

or an interrupt (DDI) mode. Group 2 devices function only in the data mode.

ERROR SIGNAL.— The error signal is activated by the KCMX under computer control and is a program-controlled function. It is normally generated in response to a format error in the operator entered data. The signal lights the error indicator on the DD device.

ENTER SIGNAL.— The enter signal is generated by the DD device when it has a data entry input ready for transmission to the controlling computer. The KCMX, when requested by the controlling computer, samples (reads) the data on the data lines from the DD device.

READ SIGNAL.— The read signal is used to activate the DD device data lines. The KCMX activates the read signal for the addressed DD device and waits 200 msec before sampling the data. When the DD device receives the read signal, the data lines back to the KCMX are activated. The KCMX waits the 200 μsec, samples the data, and inputs the data to the controlling computer.

DEMAND DIGITAL INTERRUPT (DDI) INPUT.— A demand digital interrupt (DDI) is nothing more than a demand digital device assigned to group 1 when that group is in the interrupt mode. Group 1 is placed in the interrupt mode by a computer external function command. The enter signal is processed differently in the interrupt mode. The KCMX automatically tests and honors the DDI enter signals through an interrupt priority sequence. The KCMX reads the entered data and inputs it to the controlling computer as an interrupt code rather than as a data input word. There is no delay in waiting for the computer to request a data input (DD mode).

READY DIGITAL (RD) INPUTS.— There are up to eight inputs for ready digital data (figure 13-11); KCMX addresses 63 through 71 are used for 12-bit data while address 72 is used for 30-bit words. This data is obtained from synchromechanical devices such as the radar azimuth converters (RACs). The data normally represents a digitized analog antenna position.

The eight ready digital (RD) inputs occupy separate cables and use only one control signal (enter signal) each. These eight separate signals inform the KCMX that the data on the line is valid and can be sampled. The data is sampled by the KCMX when the corresponding address is designated by the controlling computer to be interrogated and have the data entered (TDUC). If the KCMX attempts to sample the data lines and the enter signal is temporarily false, the

KCMX will delay the sampling for 300 μsec. If the enter signal is still false at the completion of this time period, the KCMX will return a data word of all ONES to the computer for that address. If at any time during this delay the enter signal becomes true, the KCMX will sample the data and gate the data into the computer input register and transfer it to the computer with an input data request (IDR). The 12 data bits from addresses 63-71 will occupy the lower 12 bits of the computer input word. Address 72 data bits occupy the entire 30-bit word.

Digital Input Channels and Digital Output Channels

The KCMX is capable of receiving and transmitting data over four 30-bit CDS I/O channels (DIC1 through DIC4 and DOC1 through DOC4). The input channels are assigned KCMX addresses 73 (DIC1) through 76 (DIC4). The DIC/DOCs (figure 13-11) maybe used for input only devices, output only devices, or a DIC/DOC pair (DIC1/DOC1, DIC2/DOC2, and so forth), which can communicate with an I/O device.

The KCMX DIC/DOCs allow the computer controlling the KCMX to communicate with four or more digital devices. The KCMX may function as a computer or as a peripheral device when communicating with the external digital devices. Devices linked by the DIC/DOCs will conform to standard CDS format 30-bit parallel transfers using either computer or peripheral control logic signals.

The DIC/DOCs themselves can be manually set to one of two data transfer formats designated peripheral (PERIPH) or computer (COMPUTE). (Both types of transfers involve 30-bit parallel data. Computers generate function codes, while peripherals generate interrupts; peripherals generate requests such as output data requests (ODRs), while computers generate acknowledgments such as output data acknowledges (ODAs), and so on.) In the peripheral format, the KCMX appears as a piece of peripheral equipment to an external computer.   In the computer format, the KCMX appears to be a computer to the external peripheral device.

The DIC/DOC interfaces have limitations. External functions can only be transmitted from the controlling computer over the DOCs. Interrupts can only be received by the controlling computer from an external device over the DICs. Devices connected using output only or input only configurations may require a DIC/DOC pair to be connected to allow both computer control by external function and device interrupt capabilities. In other words, a single DIC or DOC hookup loses the external function control capability (DIC only) or the external interrupt capability (DOC only).

DIGITAL OUTPUT CHANNELS (DOCs).— The cabling for each of the four DOCs is the same as that of a computer or peripheral output channel. A manual switch for each DOC selects either peripheral or computer interfacing for the device connected on that channel.

DOC Computer Operation.— The KCMX acts as an interface between the external device (peripheral) and the controlling computer. The KCMX accepts data one word at a time in a buffer from the controlling computer. Up to the first seven words of the buffered data may be external function commands for the external equipment. External function commands sent by the controlling computer to the KCMX set up the buffer size (number of data words) and the number of external function command words in the buffered data. The KCMX generates the external function signals for the external function commands setting up the external equipment and then transmits the remainder of the buffered words as normal computer output data. A maximum of 255 computer words (external functions and data) may be sent by the controlling computer in a single buffer.

DOC Peripheral Operation.— In the DOC peripheral operation format, the KCMX acts as an interface between the external device (computer) and the controlling computer. The data buffer from the controlling computer is inputted to the external computer as interrupts or data words. The controlling computer's external function commands define the number of interrupt words (maximum seven) that precede the data words in its output buffer.

DIGITAL INPUT CHANNELS.— The four digital input channels (DICs) are interrogated by the controlling computer on a regular basis. Each DIC is assigned an address (DIC1 address 73 through DIC4 address 76). If the data word being received by the KCMX is not an external interrupt or external function, the KCMX will wait until the DIC address is interrogated before sending the data word to the controlling computer and indicating acceptance of the word to the external device.

DIC Computer Operation.— In the DIC computer operation format, the KCMX acts as a computer to an external peripheral device. When the computer receives an input data request (IDR) from the device, the KCMX will store both the request and the input data word. Upon interrogation from the controlling computer, the KCMX will transfer the DIC data to the computer and send an input data acknowledge (IDA) to the external device.

DIC Peripheral Operation.— In the DIC peripheral operation format, the KCMX acts as a peripheral to an external computer. The KCMX generates an ODR to the external computer. The computer responds with data and an output data acknowledge (ODA). The KCMX holds the data until interrogation and transfer with the controlling computer. The KCMX then generates another ODR to the external computer.

DIC Interrupts.— The KCMX may generate interrupts to the controlling computer for DIC addresses upon receipt of external function commands from the external computer in peripheral format or external interrupts from the external peripheral device when in the computer format.

Status Signals

Sixty status signals may be received by the KCMX (figure 13-11) via status inputs connected to KCMX addresses 61 and 62. Each KCMX status address provides a 30-bit status word when interrogated by the controlling computer. The condition of each status bit in the two status words is dependent on the condition of its associated status relay coil. The status relays complete the circuit between the KCMX and the external devices generating the status signals. Supply voltages used to generate status signals include but are not limited to 26 vdc, 50 vdc, and 115 vac 60/400 Hz.

All 60 status lines and associated supply voltages are connected to the KCMX via 5 status plugboards. Each status signal relay is wired to a status signal return line on a plugboard. A plugboard is an electrical connector wired with short jumper wires to provide flexibility in the connection configuration. The plugboards are wired when the system is installed, depending on the system-configuration.

Control Signals

The control signals (figure 13-11) are generated by the KCMX in response to control word outputs from the controlling computer. Individual bits set in the two control words energize relays to send control voltages to external equipment. Once again plugboards are used to increase system flexibility.

Ready Analog (RA) Inputs

Processing of synchro inputs (ready analog data) is performed by the synchro multiplexer and synchro converter logic (figure 13-1 1). The KCMX can accept inputs from 32 three-wire synchros. Six cables are used to connect the synchro inputs and reference voltages to the KCMX. Five cables carry 6 synchro inputs and the sixth carries 2 inputs and up to a maximum of 12 reference voltage inputs. The first 24 synchro channels require 400-Hz reference voltages, while the last 8 may use either 60-Hz or 400-Hz.

The KCMX accepts either single- or dual-speed synchro system inputs. The synchro multiplexer provides the method for selecting a unique synchro address from the 32 possible synchro inputs. The KCMX, in response to a TDUC external function from the controlling computer, will convert the addressed synchro input into digital form and transmit the digitized angle (B AM) to the controlling computer. The digital logic in the KCMX allows a fixed time delay for a full conversion to take place. The conversion delay is 2 msec if a 400-Hz reference is used, or 10 msec if a 60-Hz reference is used. A **time out** of the conversion delay would cause a data word of all ONES to be returned to the controlling computer.

A single synchro-to-digital (S/D) converter processes the multiplexed synchro input. The S/D converter uses the sector method to derive the precise angle of the rotor in BAMs. The converter will perform two separate conversions, the first for the fine speed and the second for the coarse speed. The converter places the combined results as a single BAM word in its output register where the data is held until accepted by the TDUC circuits and inputted to the controlling computer. For single-speed synchros, both fine and coarse conversions are performed, but the results of the fine conversion are ignored. The bits in the BAM word that apply to the fine conversion are left blank (ZERO).

Digital-to-Synchro (D/S) Conversion

The KCMX does not have a built in D/S conversion capability. To provide this capability, one or more of the DOCs must be connected to DACs.

Controls and Indicators (KCMX)

The front panels of the KCMX (figs. 13-12 and 13-13) contain all the controls and indicators used by operating personnel. The chassis behind the front panels (A1, A2, A3, and A4) and the power supply chassis in the bottom unit (PS1) can be unlatched and run out like drawers for access to the logic board racks inside. Signals can be observed at the appropriate test points, which are given in the equipment prints. Power supply fuses appear on panel AS (power control assembly); test points for the power supply can be found by extending chassis PS1 outward.

Power Control Assembly (A5)

The power control assembly at the top of the unit (figure 13-10) contains the BLOWER ON/OFF switch and indicator, main POWER ON/OFF switch and indicator, running time meter, 3-phase BLOWER POWER fuses, and a 1-amp fuse for the -26.5 vdc power supply. An amber TEST MODE indicator will light whenever the MODE SELECTOR switch (panel A2) is in any position except NORM.

The A5 assembly also contains over-temperature warning indicators and bypass circuitry. The red
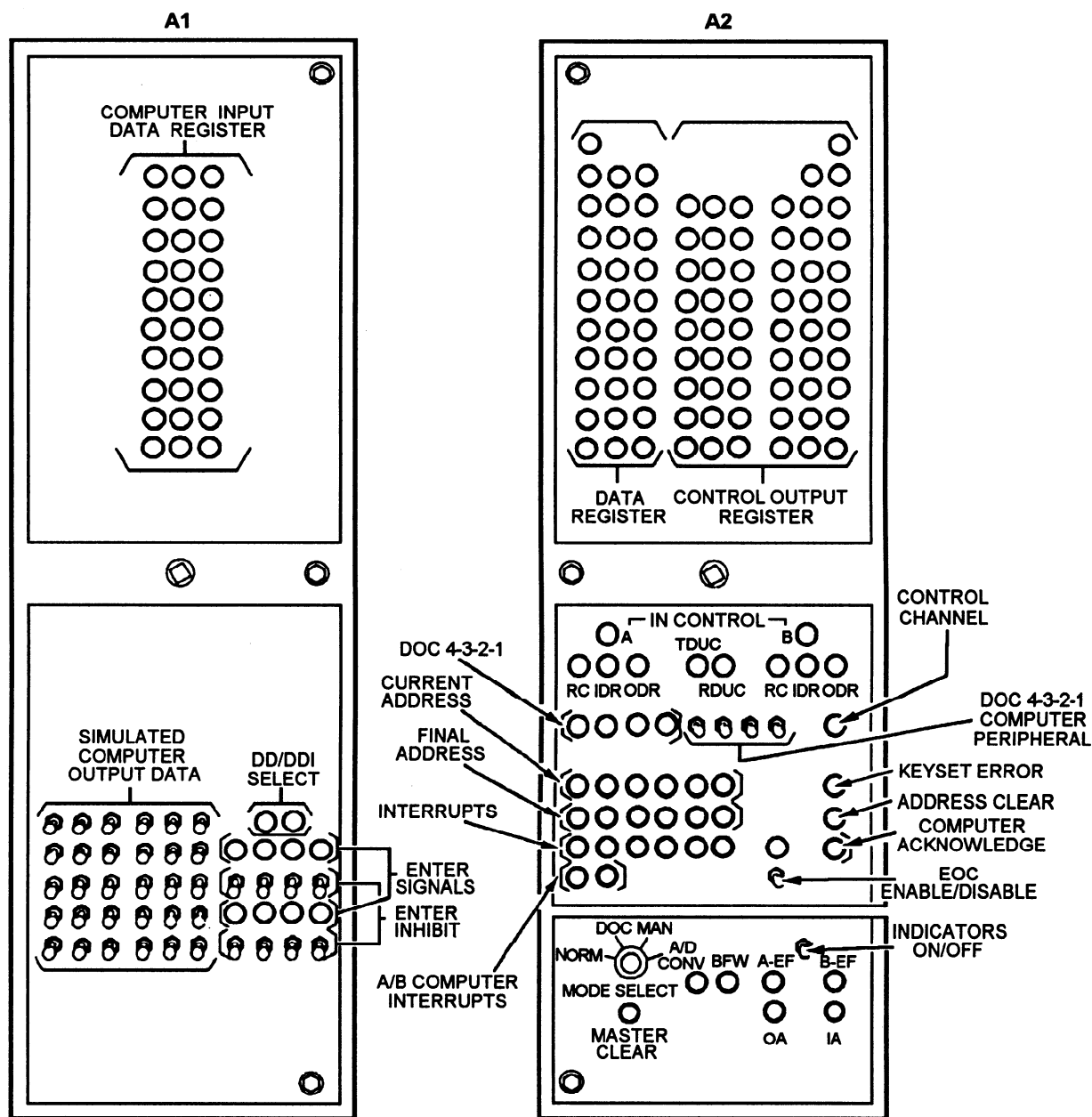
Figure 13-12.—KCMX front panels (A1/A2).
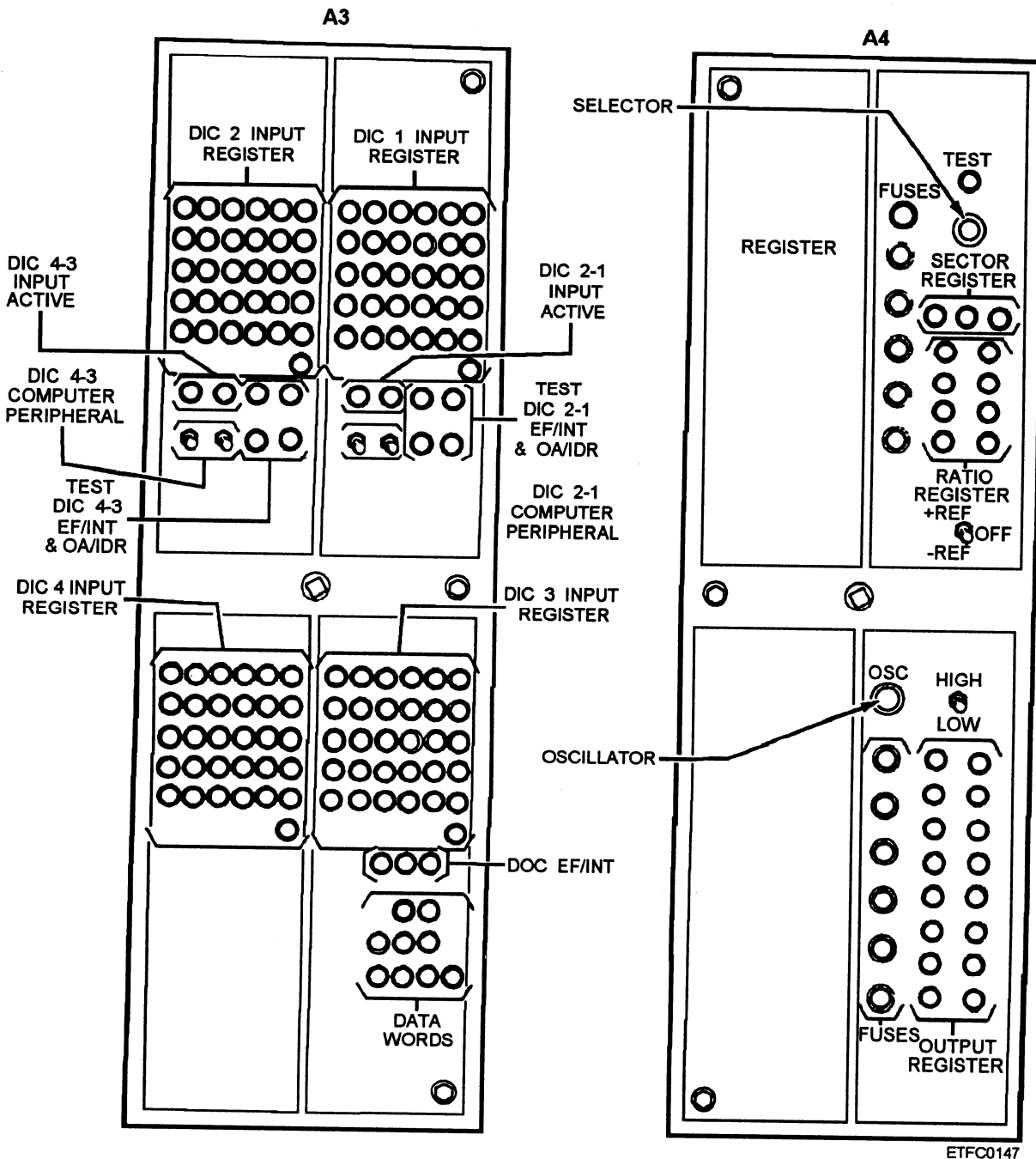
Figure 13-13.—KCMX front panels (A3/A4).

OVER-TEMP WARNING light will come on and the horn will sound when the cabinet's internal air temperature exceeds 115° F (46° C). The ALARM BYPASS will inhibit the horn if desired. The red OVER-TEMP SHUTDOWN indicator will light, and power will be removed from everything except the blowers if the cabinet's internal temperature exceeds 140° F (60° C). The red OVER-TEMP BYPASS switch/indicator can be used to bypass the over-temperature circuits under EMERGENCY conditions. The OVER-TEMP RESET pushbutton can be used to reset the horn and warning indicators.

Computer Input Data Register Panel (A1)

The upper half of the A1 panel (figure 13-12) contains the 30-bit COMPUTER INPUT DATA REGISTER. The 30 pushbutton/indicators show the contents of the computer input data register when the KCMX MODE SELECT switch (bottom of A2 panel) is in the NORM position. The pushbuttons can be used to simulate data from the KCMX to the computer when the MODE SELECT switch is not in the NORM position.

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The lower half of the A1 panel (figure 13-12) contains the SIMULATED COMPUTER OUTPUT DATA switches and the DD/DDI SELECT switches and indicators.

SIMULATED COMPUTER DATA OUTPUT SWITCHES.— These switches are used to simulate 30-bit computer external function and computer output data words from the controlling computer to the KCMX.

DD/DDI SELECT SWITCHES/INDICATORS.— These switches and indicators are used to select DD or DDI mode for the group 1 DD devices. The top two indicator/pushbuttons identify the group mode (left DD/right DDI). The pushbuttons may be used to manually switch between DD and DDI modes. The eight individual device indicators show if there is an enter signal on the line from one of the group 1 devices (addresses 1 through 10). The eight ON/OFF switches are used to control the individual device DDI enter signals. The ON position enables the device DDI enter signal, the OFF position disables it. Individual devices will not enter DDI data with these switches OFF, even if group 1 is in the DDI mode.

Digital Control Logic Panel (A2)

The upper half of the A2 panel (figure 13-12) contains the DATA REGISTER and the CONTROL OUTPUT REGISTER. The data register pushbutton/indicators are lighted to indicate the presence of data for DOC equipments. The pushbuttons may be used to enter data bits into the register for offline operations. The control output register indicates the status of the external control signals. A lighted indicator means a control signal is being generated. The pushbuttons may be used to set individual control signals during offline operations.

The lower half of the A2 panel contains the following controls and indicators: DUPLEX controls, KCMX mode controls/indicators, DOC interface controls/indicators, and KCMX interrupt controls/indicators.

DUPLEX CONTROLS.— The duplex controls (figure 13-12) are identical for both A and B computers; therefore, only the A controls/indicators are discussed.

The DUPLEX A CONTROL pushbutton/indicator, when lighted, indicates that the A computer is in control. In other than normal operation, the pushbutton may be depressed to simulate that computer A is in control. The DUPLEX A RC, DUPLEX A IDR, and DUPLEX A ODR pushbutton/indicators are lighted to indicate that the KCMX has received the request control (RC), input data request (IDR), or output data request (ODR) signals. These pushbutton/indicators may be used to monitor or, in test mode, to simulate the indicated signals.

KCMX MODE CONTROLS/INDICATORS.— The TDUC and RDUC pushbutton/indicators (figure 13-12) are lighted when the KCMX is in the associated mode. The pushbuttons may be used to simulate reception of the computer external function codes for that mode.

The MODE SELECT rotary switch (bottom of A2 panel) selects one of four operating/test modes. The NORM position permits normal KCMX operation. The DOC position enables testing of the digital output channels. The MANUAL position enables the KCMX to simulate computer operations by the use of the front panel controls. The synchro-to-digital converter may be tested in the A/D CONV position.

The MASTER CLEAR pushbutton resets all logic circuits. The INDICATORS ON/OFF toggle switch disables all indicators on the A1, A2, A3, and A4 panels. The CMPTR A EF, B EF, OA, and IA pushbuttons are used to simulate external functions, output acknowledges, and input acknowledges from the computer. The DATA pushbutton/indicator is lighted when the KCMX is in the RDUC mode and is prepared to transfer a data or control word. The pushbutton is used to enable the data transfer sequence when a simulated computer OA signal is present. The BFW indicator is lighted when the KCMX is in the RDUC mode and processing a computer buffer function word (BFW). The pushbutton is used to simulate reception of the RDUC BFW code from the computer.

The CONTROL CHANNEL pushbutton/indicator is lighted when a control word transfer takes place. The pushbutton may be used to simulate a control word transfer.

The six pushbutton/indicators labeled CURRENT ADDRESS (figure 13-12) display the octal KCMX address being interrogated by the TDUC mode. The pushbuttons may also be used to allow manual selection of a single address, or starting address of a set of addresses to be interrogated in a test mode. The FINAL ADDRESS pushbutton/indicators are used to select (test mode) or display (TDUC mode) the last KCMX address of a set of addresses being interrogated. The ADDRESS CLEAR pushbutton clears both the current and final address bit indicators.

The KEYSET ERROR pushbutton/indicator is lighted to indicate that the KCMX is in the keyset error mode. It maybe manually set to indicate reception of the computer external function keyset error bit.

DOC INTERFACE CONTROLS/INDICATORS.— In the RDUC mode, the pushbutton/indicators labeled DOC 1, 2, 3, or 4 are lighted when the buffer function word specifies a DOC transfer (DOC1-DOC4). The pushbuttons may be used to simulate a buffer function word DOC input data (ID) code. Four toggle switches (DOC 4, 3, 2, 1 COMPUTER/PERIPHERAL) are used to manually select the DOC operational mode.

KCMX INTERRUPT CONTROLS/INDICATORS.— In the interrupt indicators (A/B COMPUTER INTERRUPTS), CMPTR A INT and CMPTR B INT pushbutton/indicators are lighted when an interrupt signal is on the computer (A or B) input line. The buttons may be used to simulate an interrupt condition.

The six interrupt pushbutton/indicators (INTERRUPTS) are left to right; ILL ADR, EIC, EEC, DIC REQ, DD, and ID ERR. The pushbuttons for the interrupt indicators may be used to simulate the associated interrupt condition.

When an illegal address (octal 00 or 77) is detected in either the current or final address registers, the ILL ADR indicator is lighted. The EIC pushbutton/indicator is lighted to indicate an end-of-input cycle. The EEC indicator is lighted to indicate when the KCMX has completed a keyset error transmission. The DIC REQ indicator is lighted when the digital input channel request interrupt is active. The DD indicator is lighted when an enter signal is received from a group 1 keyset and the group is in the interrupt mode. When the KCMX detects an error in the buffer function word ID codes, the ID ERR indicator is lighted.

The EOC ENABLE/DISABLE toggle switch is used to enable or disable the sending of an end-of-output cycle (EOC) interrupt to the computer. The indicator above the toggle switch indicates the detection of an end-of-output cycle condition.

The COMPUTER ACKNOWLEDGE (CA) pushbutton/indicator is lighted when a computer (A or B) has been granted control of the KCMX and the KCMX sends a control acknowledge interrupt to the computer. The pushbutton may be used to simulate the CA interrupt.

Digital Input Channel (DIC) Logic Panel (A3)

The A3 panel (figure 13-13) contains the registers, controls, and indicators for monitoring and testing DIC operations. There are four 30-bit registers labeled DIC 1 INPUT REGISTER through DIC 4 INPUT REGISTER. These registers are used to indicate the status of the bit positions for each channel. In KCMX operations other than the normal mode, each bit position may be set manually using the pushbutton/indicator.

Each channel has its own toggle switch for computer or peripheral mode selection, two TEST pushbutton/indicators, and an INPUT ACTIVE pushbutton/indicator. The input active indicators are lighted when an interrogation for the associated channel is being performed.

The two TEST pushbutton/indicators for each channel indicate the status of external functions or interrupts (EF/INT) and output acknowledges or input data requests (OA/IDR). The DIC mode selected determines which of the signals is being displayed. The DIC computer uses EF and OA, while the DIC peripheral uses INT and IDR.

The lower portion of the A3 panel contains some pushbutton/indicators used with DOC operations. DOC EF/INT is a three-stage counter used to determine the number of DOC EF or INT words in an output buffer (maximum of 7). The DATA WORDS counter keeps track of the number of data words in an output buffer (maximum of 191).

S/D Converter/Multiplexer Panel (A4)

The controls and indicators for the synchro-to-digital converter and multiplexer are contained on the A4 panel (figure 13-13). There are 12 indicating fuses (F1-F12) for the 12 reference input transformers. An indicator lights on the fuseholder when the reference voltage is present and the associated fuse is open.

The TEST indicator lights when the seven-position SELECTOR switch is in any position other than normal (NORM). The SELECTOR switch, in any position but normal generates a simulated single-speed synchro angle. The following is a summary of the switch positions and angles:

POSITION	ANGLE
1	0
2	60
3	120
4	180
5	240
6	300
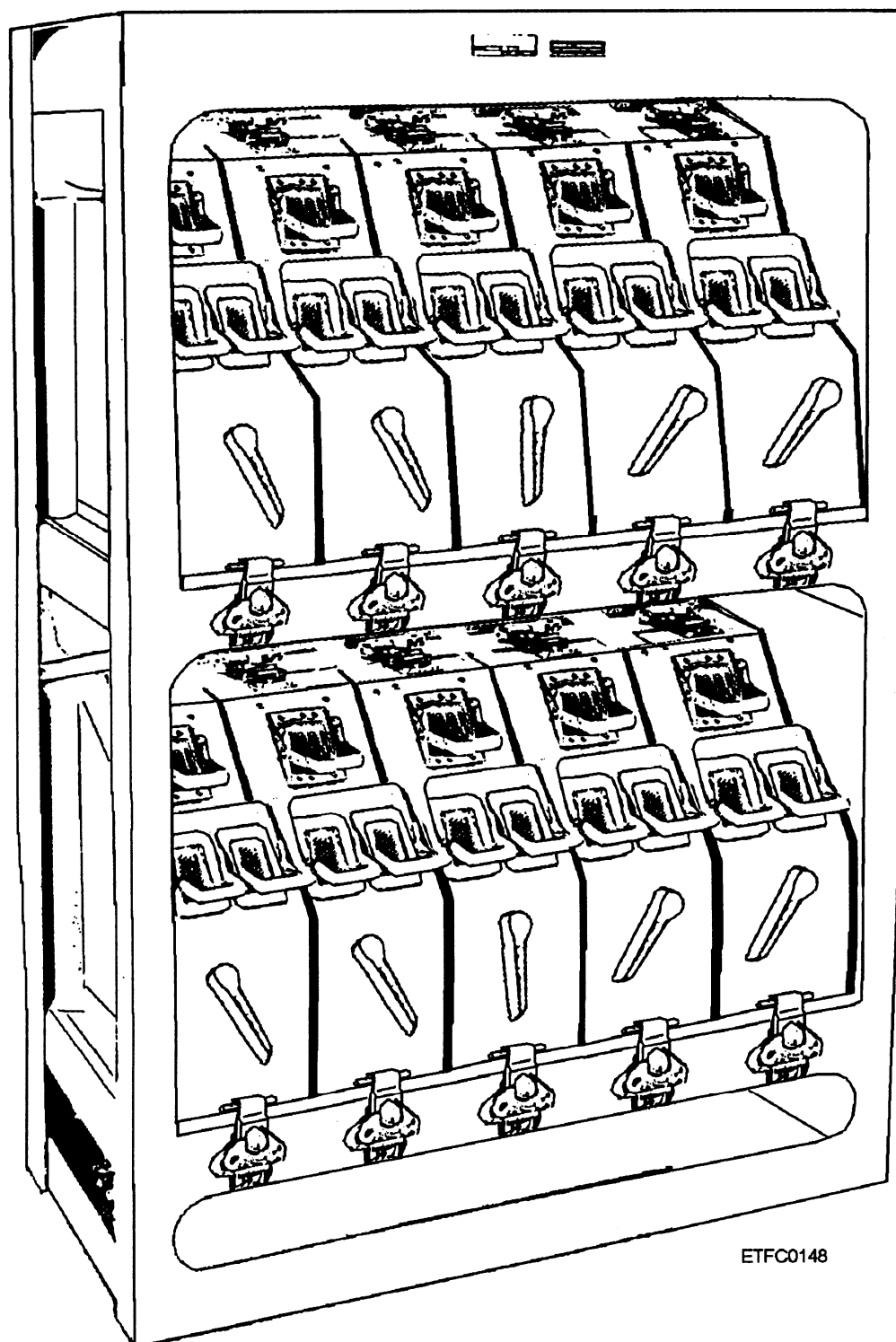
Figure 13-14.—Manual switchboard.

The SECTOR REGISTER consists of three pushbutton/indicators. The register displays the sector number of the 60-degree sector in which the rotor is located. The pushbuttons may be used to simulate a sector angle. The eight pushbutton/indicators of the RATIO REGISTER indicate or simulate the binary ratio angle.

The +REF/OFF/-REF toggle switch allows selection of positive (+REF) or negative (-REF) reference voltage. The switch is set to the OFF position for normal operations. The OSCILLATOR potentiometer is used to vary the frequency of the S/D converter test circuits from 2 to 100 Hz. With the HIGH/LOW toggle switch in the HIGH position, the S/D converter is enabled for continuous recycling when in the test mode. When the switch is in the LOW position, the recycling rate can be varied from 2 to 100 conversions a second using the OSCILLATOR potentiometer.

The OUTPUT REGISTER has 15 pushbutton/indicators and a clear pushbutton. The register indicates the 15-bit BAM output of the S/D converter. Each bit-position indicator equates to a degree value portion of the summed synchro-mechanical angle.

ETFC0149
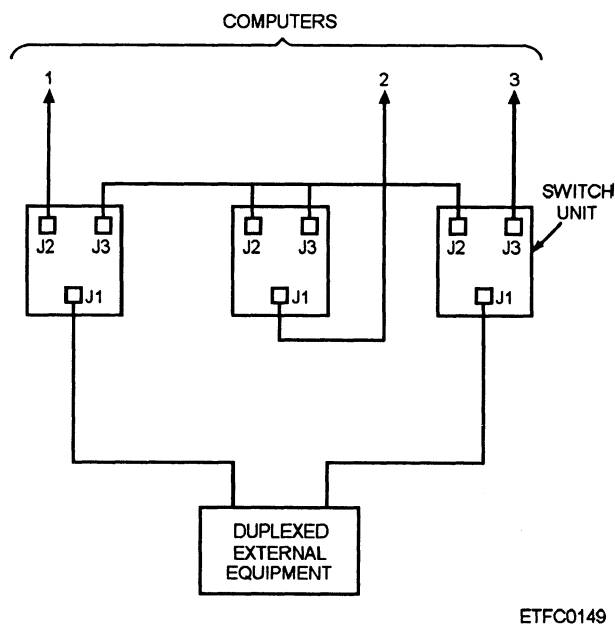
Figure 13-15.—Sample manual switching configuration.

TOPIC 3—SWITCHBOARDS

Shipboard tactical data system devices are interconnected with each other and with equipments in other shipboard subsystems through switchboards. Combat systems use two major types of switchboards: digital switchboards and analog switchboards.

Digital switchboards primarily interconnect digital devices. These types of interfaces include computer-to-computer interfaces and computer-to-peripheral devices and other serial or parallel digital interfaces.

Analog switchboards provide the interconnection for analog devices and signals including control and status signals, synchro signals, and linear signals. In addition, analog switchboards provide supply and return voltages and reference voltages for analog signal exchanges. Most current shipboard combat direction systems use a combination of analog and digital switchboards to completely interface CDS equipments with each other and with other shipboard subsystems.

DIGITAL SWITCHBOARDS

The two basic types of shipboard digital switchboards are manual switchboards and remotely controlled switchboards.

Manual switchboards are made up of variable configurations of three-position or five-position switches (figure 13-14). Each switch must be manually positioned for the interconnection required by the current system configuration. At least two manual switches, one for input and one for output, are required for each I/O device or computer channel to allow for the complete range of system configuration requirements (figure 13-15). Manual switchboards are for the most part being replaced by remotely controlled switchboards.

Remotely controlled switchboards (figure 13-16) allow for configuration changes to be controlled from one or two remote computer switching control panels (CSCPs) (figure 13-17). The actual switch configuration and data routing take place in the CDS digital fire control switchboard (DFCS). This greatly reduces the time required for configuration changes in the event of equipment casualties.

As examples of DFCS and CSCP we are using the Mk 70 Mod ( ) DFCS and the Mk 328 Mod ( ) CSCP. The Mod numbers of the DFCS and CSCP will vary with the ship class on which they are installed. For training purposes we refer to the Mk 70 as the DFCS and the Mk 328 as the CSCP.

DIGITAL FIRE CONTROL SWITCHBOARD (DFCS)

The digital fire control switchboard (DFCS) (figure 13-16) provides data routing, power monitoring, action cutout (ACO) switching, and digital switching. To perform these functions, the switchboard uses remotely operated switches and other assemblies. The switches route digital signals through the switchboard during normal operation. The digital signals consist of groups of parallel bits, which form digital words. The digital words are transmitted between computers, associated peripheral equipment, and digital equipment in other subsystems as shown in figure 13-18. The switches also can be used to interrupt or redirect signal flow manually during maintenance operations.
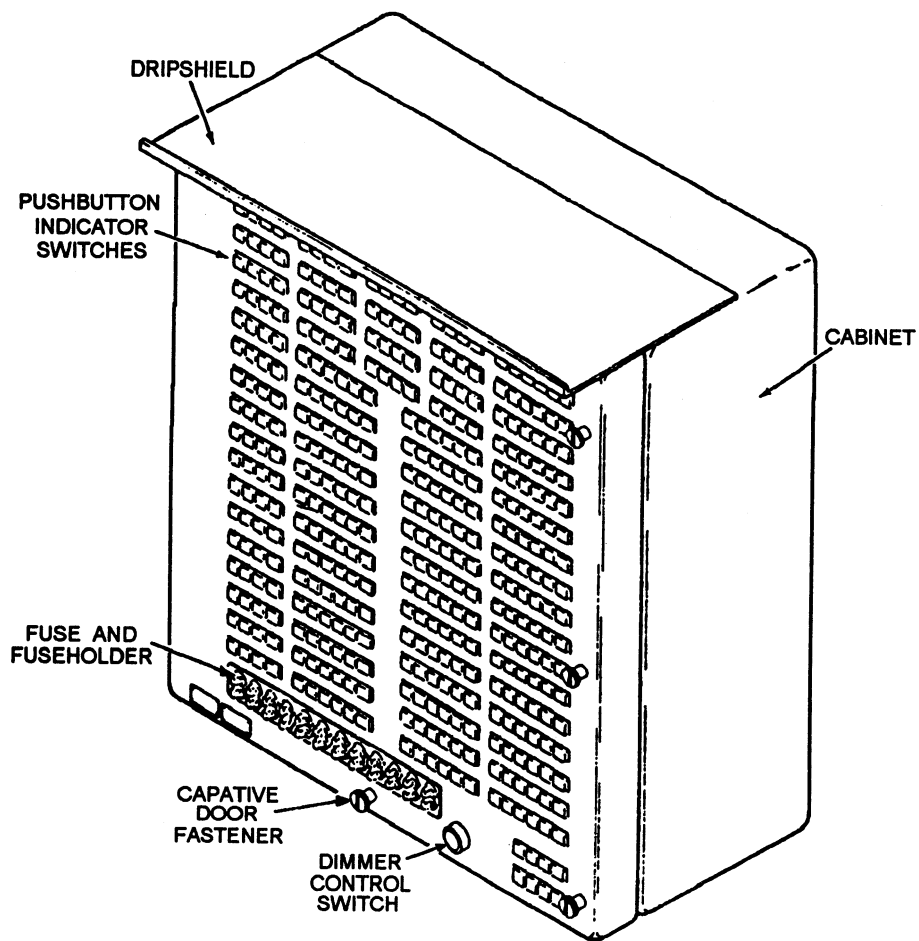
Control and status signals are normally used to initiate the switching action and monitor the status of the switch positions. The CSCP generates control signals to select the desired switch configuration on the switchboard. Status signals from the switchboard light indicators on the CSCP to display the current switching configuration. In a casualty situation, manual positioning of switches can be performed.

The DFCS is composed of two or more switchboard sections (figure 13-16) covered with variable configurations of switch panels. Each panel type performs a specific function. The 24 panels per section are normally arranged in groups according to the functions performed by the panels. The front panel of each switchboard section is hinged on the left side to
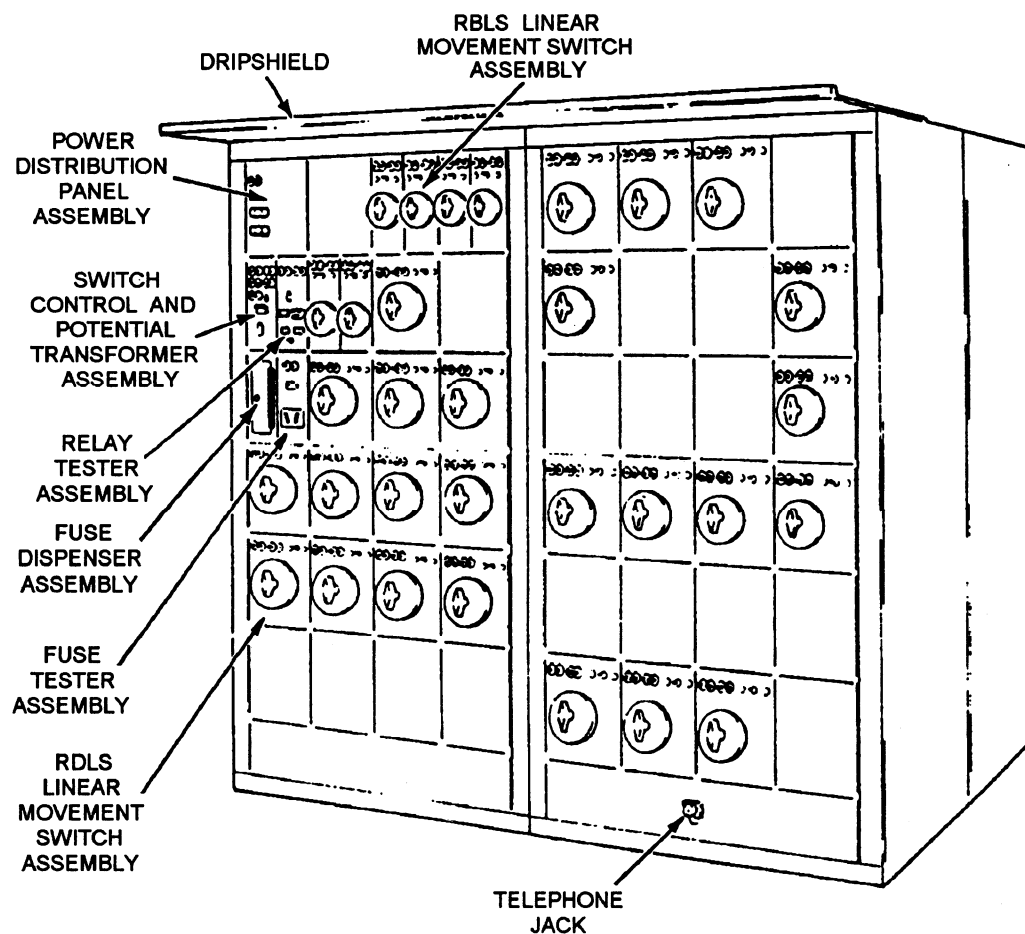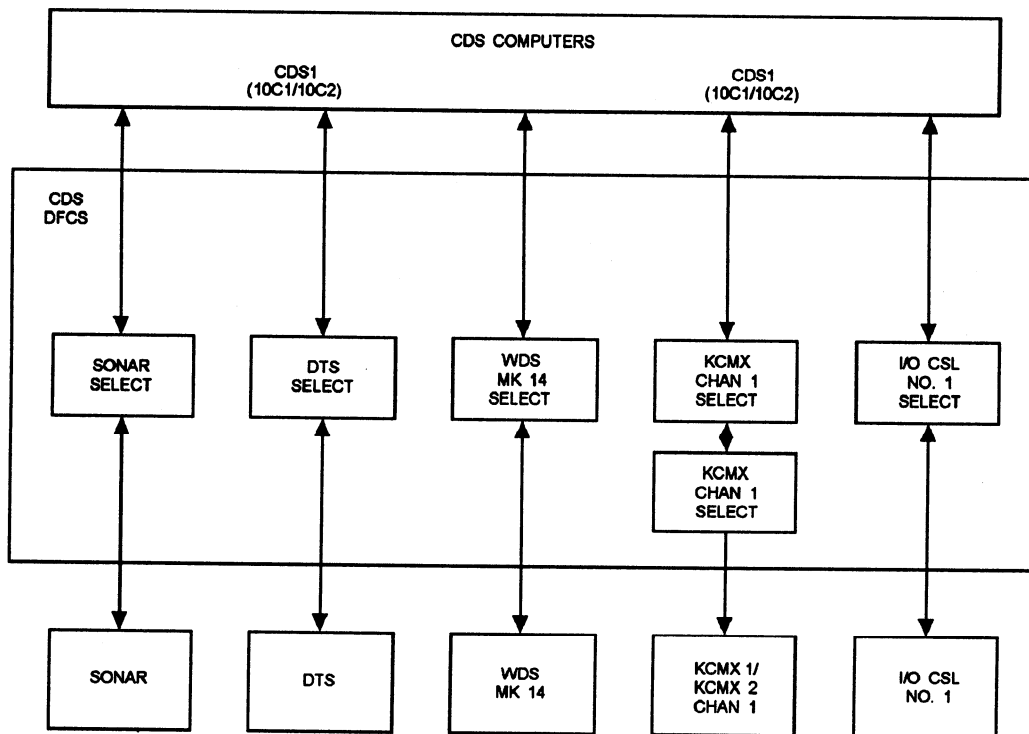

Figure 13-16.—Digital fire control switchboard (DFCS).

38NV0097

DRIPSHIELD

PUSHBUTTON
INDICATOR
SWITCHES

CABINET

FUSE AND
FUSEHOLDER

CAPATIVE
DOOR
FASTENER

DIMMER
CONTROL
SWITCH

FCNP0036

Figure 13-17.—Computer switching and control panel (CSCP).

CDS COMPUTERS

CDS1
(10C1/10C2)

CDS1
(10C1/10C2)

CDS
DFCS

SONAR
SELECT

DTS
SELECT

WDS
MK 14
SELECT

KCMX
CHAN 1
SELECT

I/O CSL
NO. 1
SELECT

KCMX
CHAN 1
SELECT

SONAR

DTS

WDS
MK 14

KCMX 1/
KCMX 2
CHAN 1

I/O CSL
NO. 1

ETFC0150

Figure 13-18.—Equipment interconnection through the CDS DFCS.

allow access to the interior of the switchboard. The interior of the switchboard (figure 13-19) contains a system of modules and terminal board connectors that allow ship's wiring to be interconnected to the appropriate switch panels.

The switchboard panel locations are numbered for identification purposes starting at the upper left corner of the switchboard. The numbering continues from top to bottom, left to right. Each panel is marked with a designation plate mounted on the upper-left corner of the panel assembly or with a blank plate.

Power Distribution Panel

The power distribution panel (figure 13-20) provides a visual indication of power supplied to the switchboard. Six indicators are mounted on the front of the panel and lighted when the appropriate power has been applied to the panel and distributed to the remainder of the switchboard.

Linear Movement Switch Assemblies

The majority of panel assemblies are linear movement switch assemblies. These assemblies route a specific number of circuits. The linear movement switch assemblies are normally positioned by control signals from the CSCP, but they may be manually positioned.

There are two types of linear movement switch assemblies, the R3DLSO-1B/R5DLSO-1B (figure 13-21)
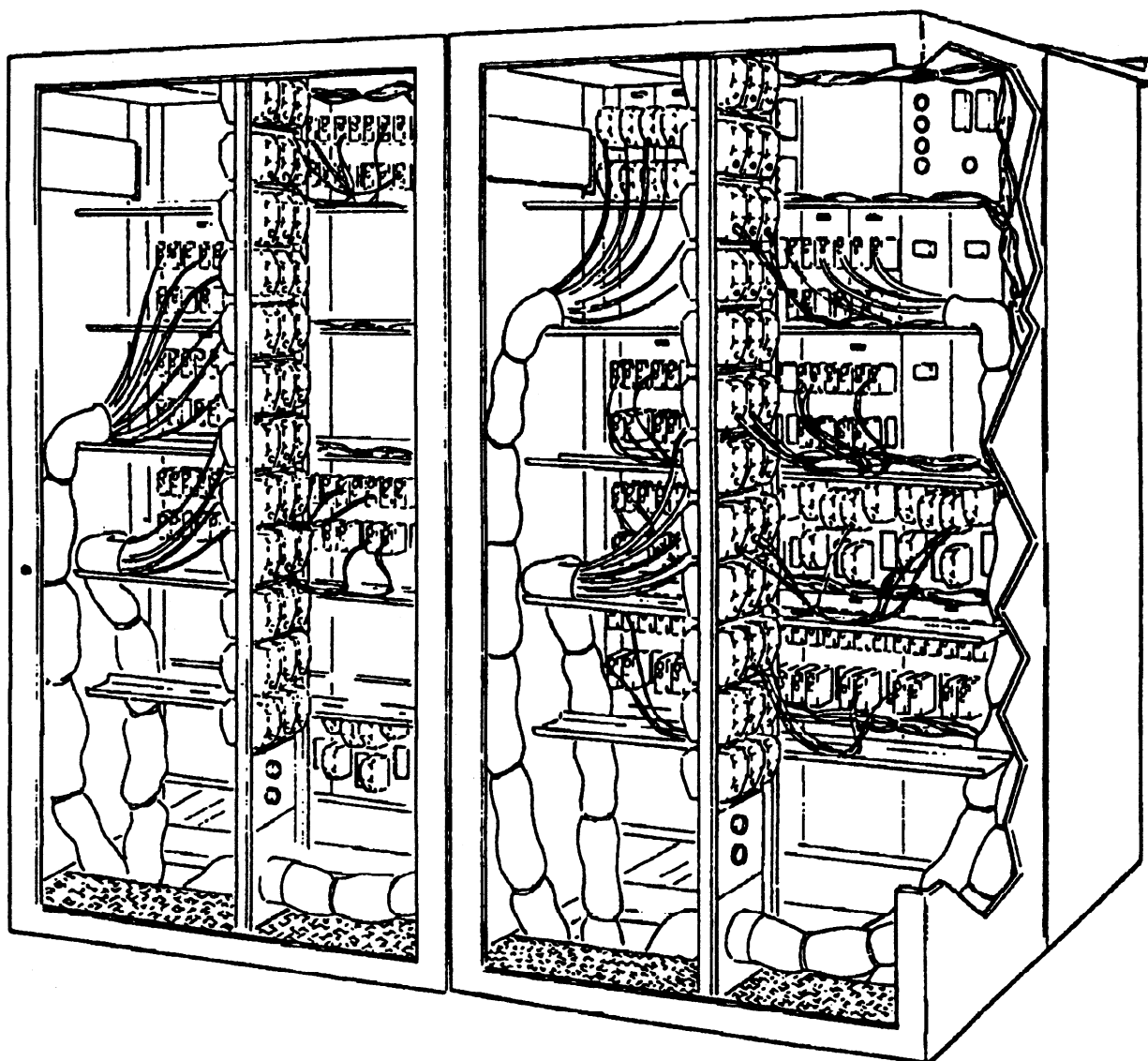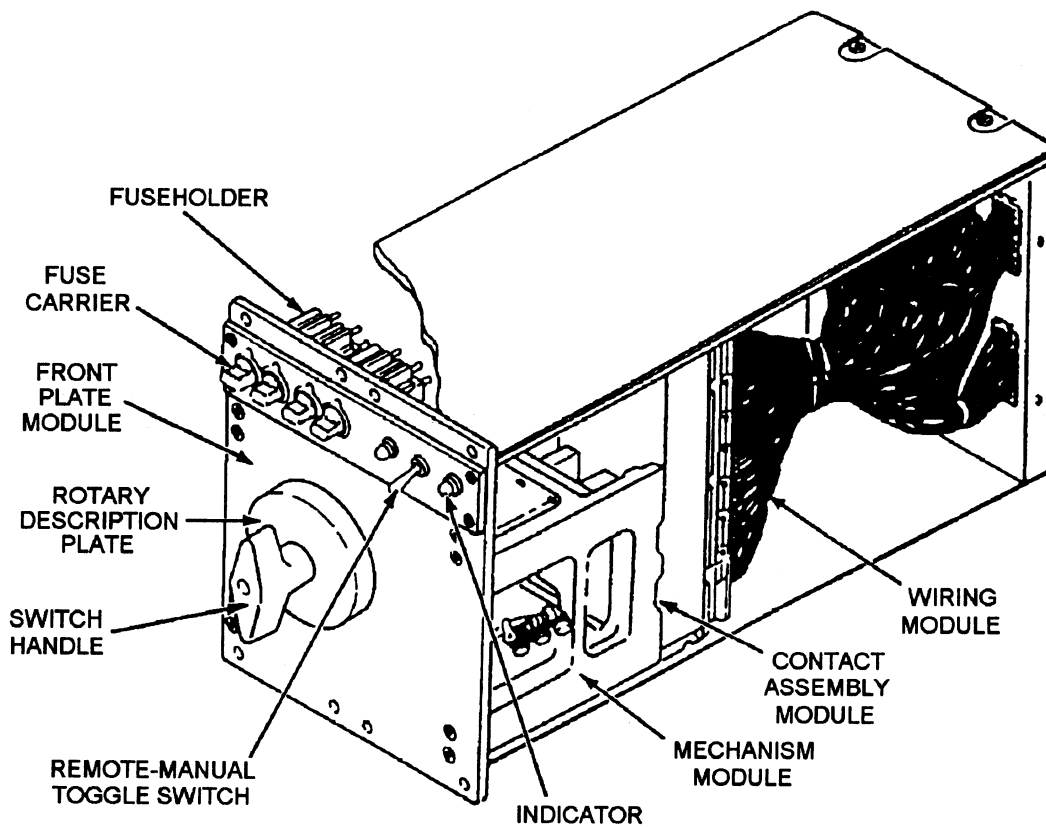

ETFC0151

Figure 13-19.—DFCS interior.

13-28
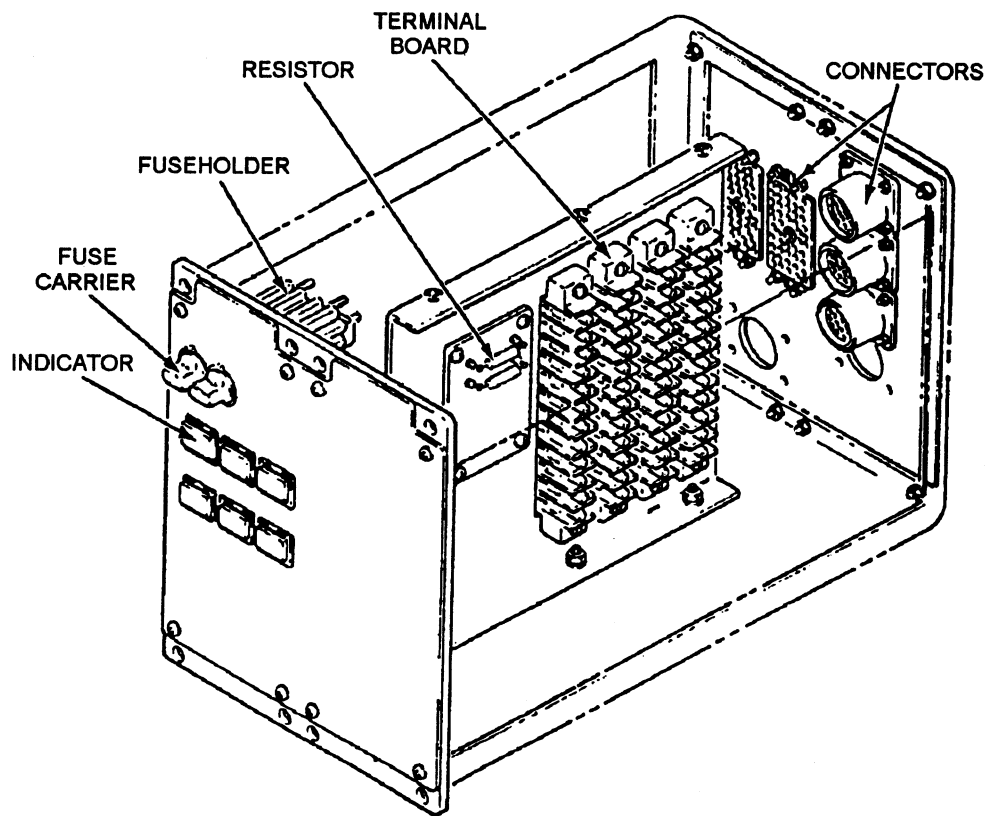
Figure 13-20.—Power distribution panel assembly.

ETFC0152

ETFC0153

Figure 13-21.—R3DLSO-1B/R5DLSO-1B linear movement switch assembly.

13-29

and the R3BLSO-1C/R5BLSO-1C (figure 13-22) assembly. The assemblies differ from each other in the front panel organization and in the wiring module capabilities. The panels provide different arrangements of 20-pin, 38-pin, 117-pin, and 120-pin connectors.

Both types of linear switches have similar mechanism and contact assembly modules. The mechanism assembly module contains the drive motor, the control circuit module, and the control transformers for remote operation of the switch. The contact assembly module consists of a stationary control plate and a moveable plate to perform the switching functions.

The linear switches perform either three-position (R3) or five-position (R5) switching functions. The three-position switches are used for NORMAL/ALTERNATE configuration switching with an OFF position for circuit isolation. The five-position switches have an OFF position with the four other switch positions being used for circuit configuration or reconfiguration. For an example, see figure 13-23.

One channel of a duplexed magnetic tape unit can be switched between four separate CDS IOC channels or isolated in the OFF position.

The front panels of both types contain a REMOTE-MANUAL toggle switch. When the switch is in the REMOTE position, the CSCP has control of the switch position (normal operating mode). When the toggle switch is in MANUAL, the switch must be positioned using the switch handle.

Switch Control and Potential Transformer ACO Assembly

The switch control and potential transformer action cutout (ACO) assembly (figure 13-24) provides control voltages for bench testing of the linear movement switches. The control voltages are provided through test cables from the test jack to the linear switch assembly under test.
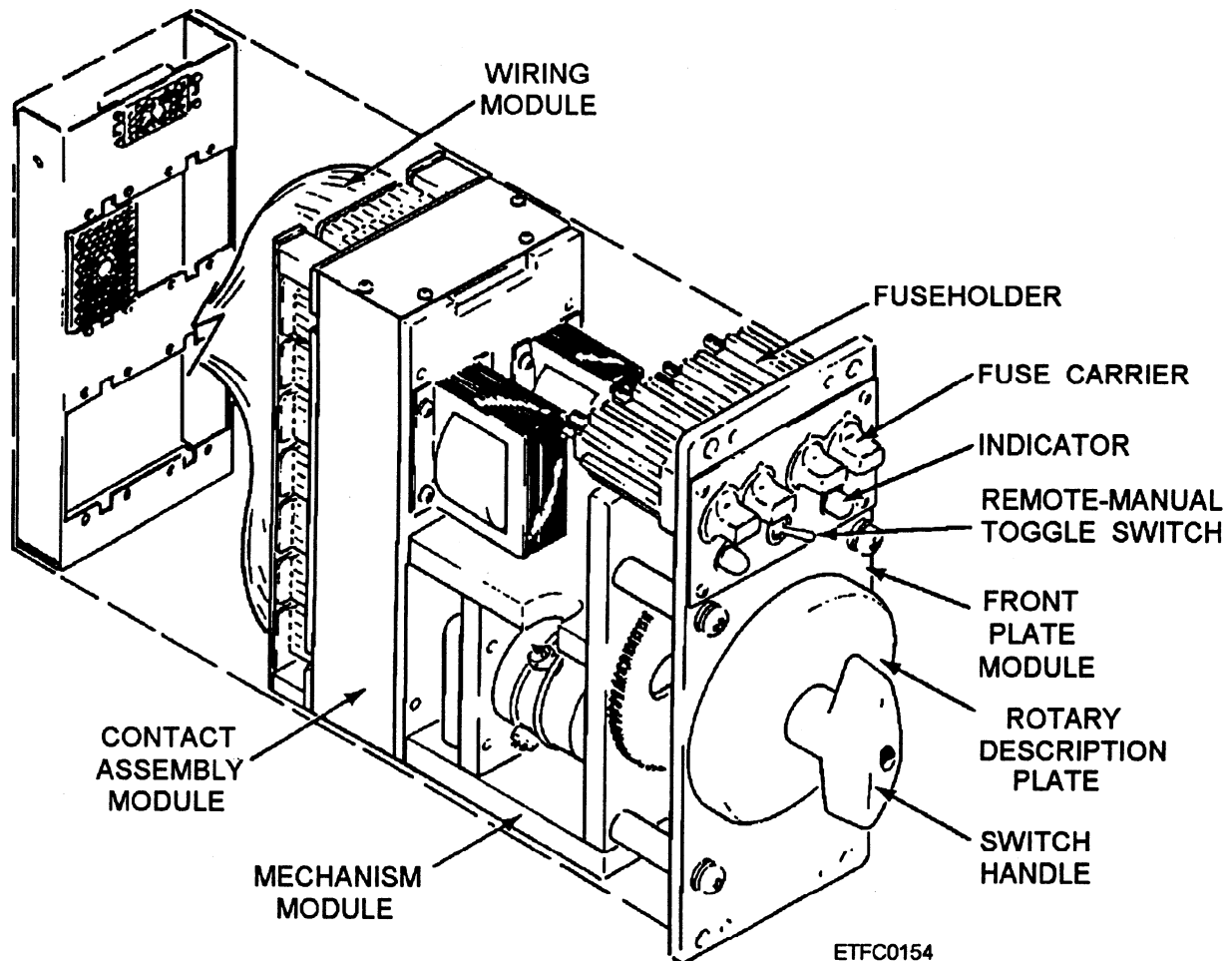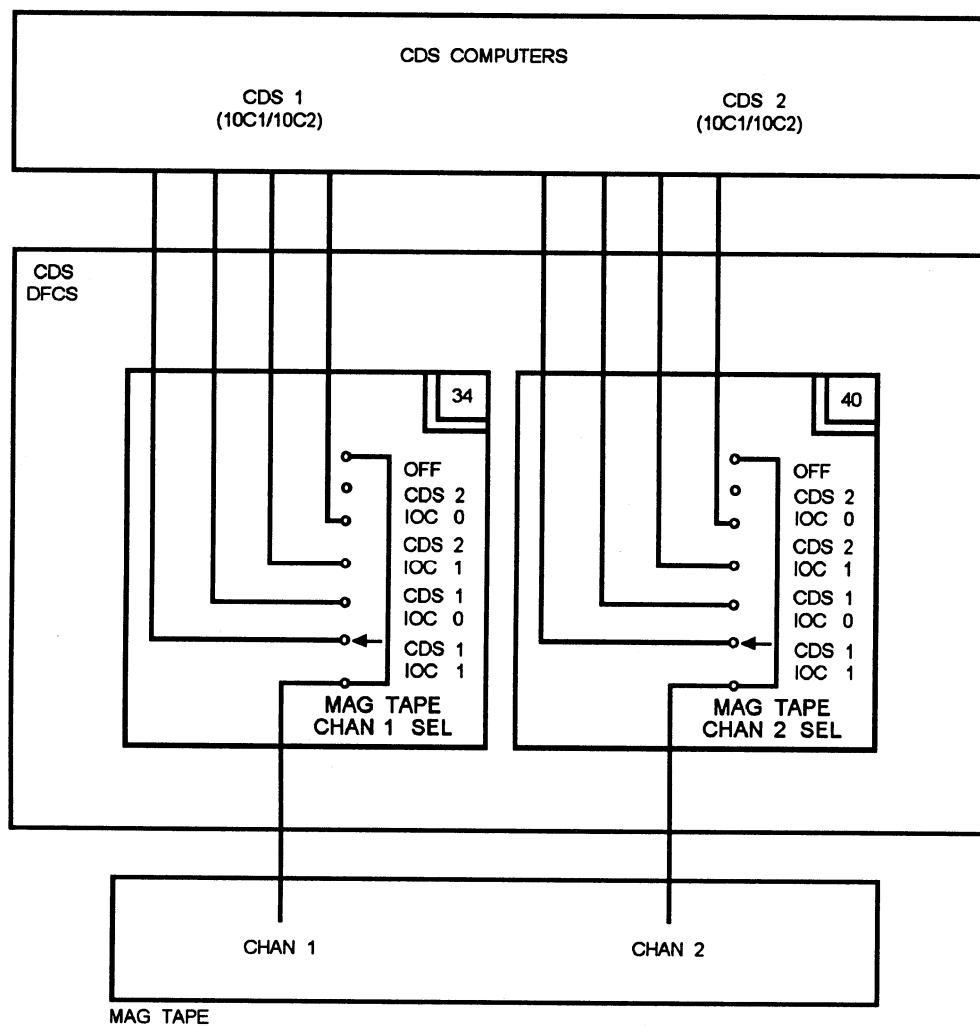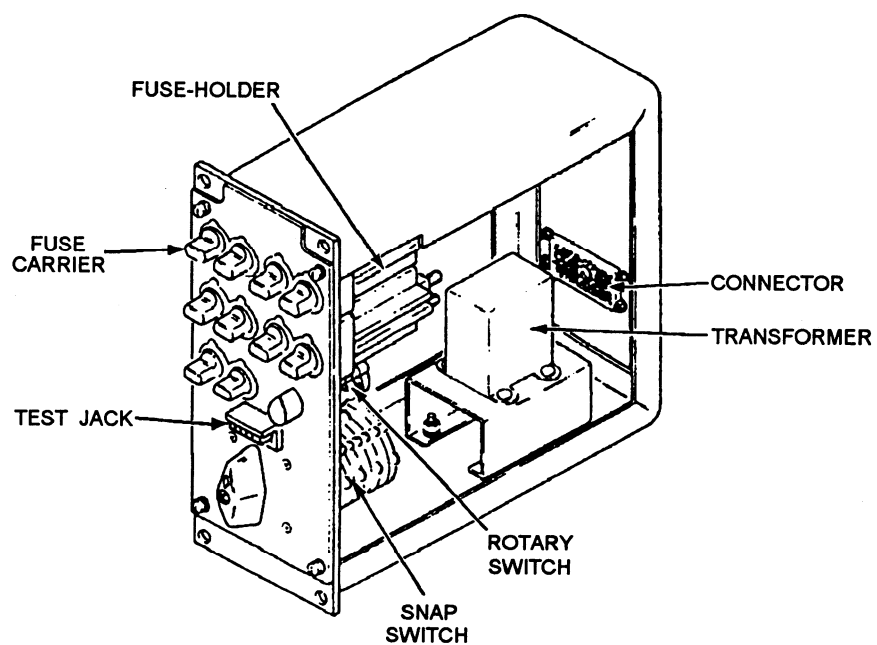

Figure 13-22.—R3BLSO-1C/RSBLSO-1C linear movement switch assembly.

CDS COMPUTERS

CDS 1
(10C1/10C2)

CDS 2
(10C1/10C2)

CDS
DFCS

34

OFF
CDS 2
IOC 0
CDS 2
IOC 1
CDS 1
IOC 0
CDS 1
IOC 1

MAG TAPE
CHAN 1 SEL

40

OFF
CDS 2
IOC 0
CDS 2
IOC 1
CDS 1
IOC 0
CDS 1
IOC 1

MAG TAPE
CHAN 2 SEL

CHAN 1

CHAN 2

MAG TAPE

ETFC0155

Figure 13-23.—Magnetic tape interconnection through the DFCS.

FUSE-HOLDER

FUSE
CARRIER

CONNECTOR

TRANSFORMER

TEST JACK

ROTARY
SWITCH

SNAP
SWITCH

ETFC0156

Figure 13-24.—Switch control and potential transformer ACO assembly.

13-31

FUSEHOLDER

CONNECTOR

FUSE CARRIER

RESISTORS AND DIODES

ROTARY SWITCH

TERMINAL BOARD

RELAY SOCKET 16-PIN

RELAY SOCKET 10-PIN

INDICATOR

RELAY SOCKET 8-PIN FUSEHOLDER

TOGGLE SWITCH

ETFC0157
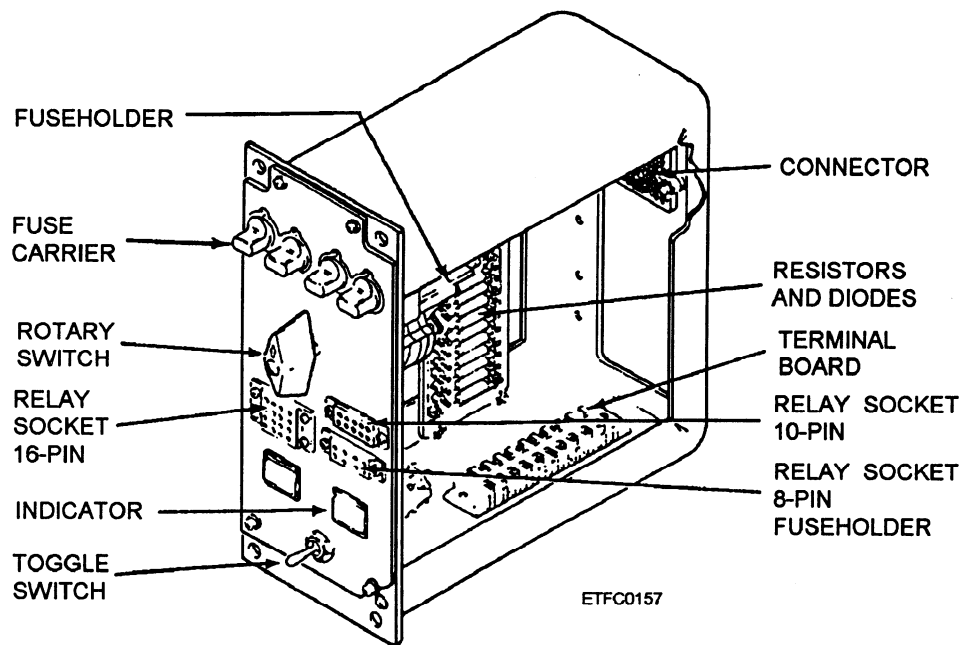
Figure 13-25.—Relay tester assembly.

Relay Tester Assembly

The relay tester assembly (figure 13-25) provides the facilities for testing each type of relay used in the DFCS and the CSCPs. Relay sockets are provided for 8-, 10-, and 16-pin relays. The rotary switch is used to select the appropriate relay coil voltage. The toggle switch is used to energize/deenergize the relay coil. The indicator lamps indicate the state of the relay under test (ENERGIZED/DEENERGIZED).

Fuse Tester Assembly

The fuse tester assembly (figure 13-26) is used to test fuses for continuity. The POWER ON PBI is used to apply power to the fuse tester. The POWER ON indicator will light when the tester is on. When a good fuse is placed across the contact strips, the CONTINUITY INDICATOR light will come on. A blown fuse placed across the contact strips will not light the indicator, since there is no current path through the fuse.
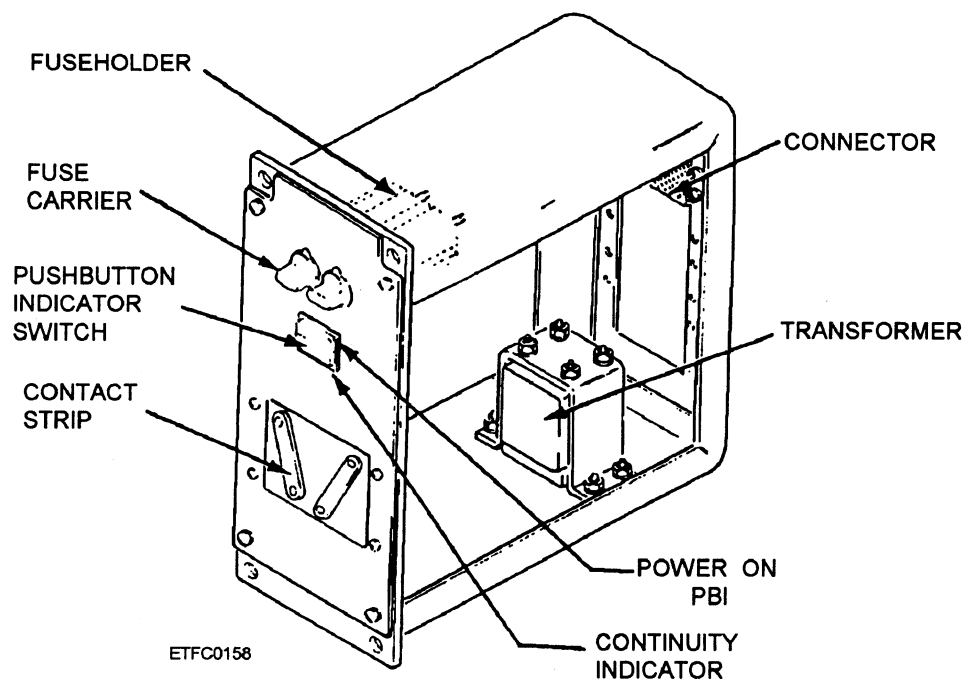

FUSEHOLDER

CONNECTOR

FUSE CARRIER

PUSHBUTTON INDICATOR SWITCH

TRANSFORMER

CONTACT STRIP

POWER ON PBI

ETFC0158

CONTINUITY INDICATOR

Figure 13-26.—Fuse tester assembly (DFCS).

13-32

Computer Switching and Control Panel (CSCP)

The two computer switching and control panels (CSCPs) are used to make switch assignments on the DFCS (controlling CSCP front panel). Switch assignments are made by depressing the associated pushbutton/indicator (PBI) on the controlling CSCP front panel (figure 13-27). The CSCP will generate a control signal to the appropriate DFCS linear switch assembly, which will respond with a status signal when it is in the assigned position. The PBI will light when the switch is in the commanded position.

Four colors are used for PBI indicators: white, red, green, and yellow. White indicates the linear slide

ETFC0159
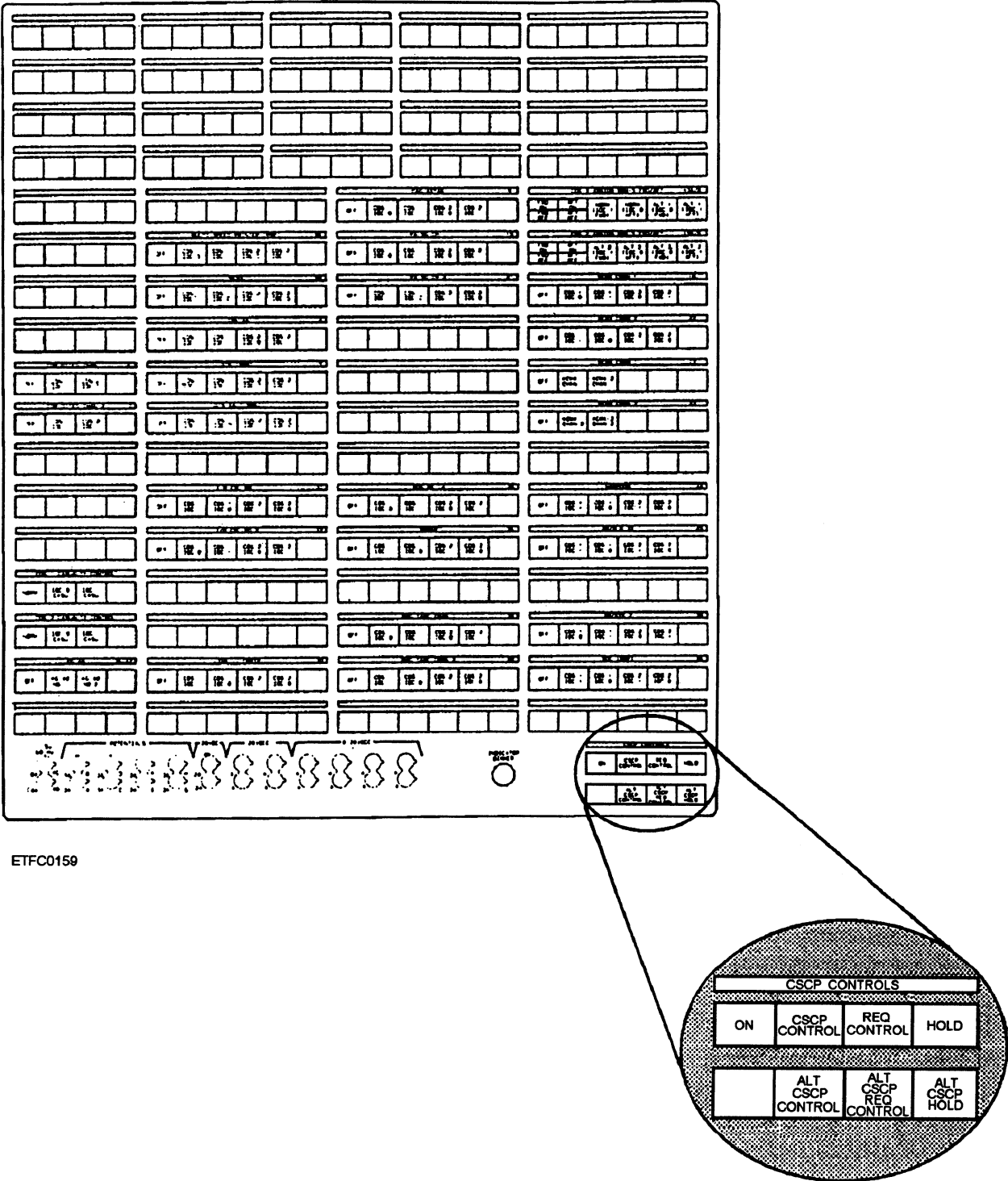
Figure 13-27.—CSCP controls and indicators.

switch position is in the ON position. Red indicates the switch is in the OFF position. Green indicates the switch is in the NORMAL position, while yellow indicates the switch is in the ALTERNATE position. Figure 13-27 shows an example of a typical CSCP configuration. The number and functional assignment of PBIs vary from ship to ship.

The PBIs in the lower right comer of the CSCP front panel shown in figure 13-27 are used to apply power to the CSCP PBIs (ON), to indicate current CSCP control status (CSCP CONTROL or ALT CSCP CONTROL), and to transfer control from the controlling CSCP to the alternate CSCP (REQ CONTROL, HOLD, ALT CSCP REQ CONTROL, and ALT CSCP HOLD). Manual PBI actions are required at both CSCPs to transfer control between panels.

At the requesting CSCP, depression of the REQ CONTROL PBI will cause the ALT CSCP REQ CONTROL indicator to light red on the controlling CSCIP. The REQ CONTROL PBI will flash red on the requesting CSCP until the operator of the controlling CSCP depresses ALT CSCP CONTROL PBI, giving control to the requesting CSCP. The CSCP CONTROL light will come on when the requesting CSCP is in control and the flashing light will go out. The HOLD PBIs are used to indicate refusal to transfer control.

SHIP, SWITCHBOARD, AND COMPUTER SWITCHING CONTROL PANEL (CSCP) WIRING

Switchboard and CSCP wires connect assemblies and components inside the switchboard and CSCP. Ship's cables are individually plug-connected to panel connectors in the switchboard. Ship's cables are identified by a cable group number and cable type.

Ship's cables, switchboard wires, and CSCP harness wires use plastic sleeves or metal tags for marking. Each ship wire has a marking bearing the ship's wire number. When required, switchboard and CSCP wires have plastic marking sleeves at each end. The sleeves identify the terminals at both ends of the wire. Separate wiring codes are used for ship's wires, switchboard wires, and CSCP wires.

The ship's wire marking codes are system oriented. They consist of an alphanumeric code that identifies the signal being carried by function number, circuit designation, and assigned wire number. A typical ship's wire code number is shown in table 13-4.

Table 13-4.—A Typical Ship's Wire Code Number

WIRE CODE NUMBER: 51-PD-713		
51	PD	713
FUNCTION NUMBER	CIRCUIT	WIRE NUMBER

There are eight types of PANEL ASSEMBLY connectors used in the switchboard. These connectors are used for the linear movement switch assemblies, fuse tester assembly, relay tester assembly, and power distribution assembly. They consist of various types of 120-, 117-, 104-, 85-, 38-, 20-, 10-, and 3-pin connectors. For wiring and maintenance purposes, a common alphanumeric designation system is used to identify specific circuit connections, as shown in table 13-5.

Table 13-5.—Panel Connection Cable Code

PANEL CONNECTOR CODE: PP-36-D-C			
PP	36	D	C
PANEL CONNECTOR PLUG (PJ FOR JACK)	PANEL LOCATION	CONNECTOR LETTER	PIN LETTER

Within the switchboard are what are known as matrix panels. The matrix panels interconnect the signal paths between the ship's wiring and the assembly panels. The designation codes for matrix panel connections are shown in table 13-6.

Table 13-6.—Matrix Panel Connection Code

MATRIX PANEL CONNECTION CODE: JC-1-A-A			
JC	1	A	A
MATRIX PANEL DESIGNATOR	SECTION NUMBER	MODULE	CONNECTOR DESIGNATOR

Intersection connectors are used to the switchboard sections together. Intersection connector codes are identified in table 13-7.

Table 13-7.—Intersection Connector Code

INTERSECTION CONNECTOR CODE: JR-1-A-A			
JR	1	A	A
INTERSECTION CONNECTOR	SECTION NUMBER	MODULE	CONTACT DESIGNATOR

The CSCP uses two types of connectors, a 10-pin connector and an 85-pin connector. The 10-pin connetors are designated JA, JB, JN, and JP. The 85-pin connectors are designated JC through JG, JH, and JK. The alphanumeric identification shown in table 13-8 is used for CSCP connectors.

Table 13-8.—CSCP Connector Code

CSCP CONNECTOR CODE: JC-C	
JC	C
CSCP CONNECTOR DESIGNATOR	CONTACT DESIGNATOR

ANALOG SWITCHBOARDS

Analog switchboards are similar in design to the Mk 70 DFCS. The switchboard is made up of a variable number of switchboard sections. The number of sections required will vary with the analog interface requirements of the shipboard system.

Each switchboard section consists of front and rear cabinets (figure 13-28). The front cabinet contains the panel assemblies. The rear cabinet contains removable modules on which are mounted the ship's cable connectors.

Each switchboard section contains 36 panels of various types mounted on the door of the front cabinet. The panels are numbered starting with panel 1 in the upper left-hand corner in section 1 and progressing consecutively downward in each column and successively to the right. The door in each switchboard section allows access to the section interior.

38NV0156
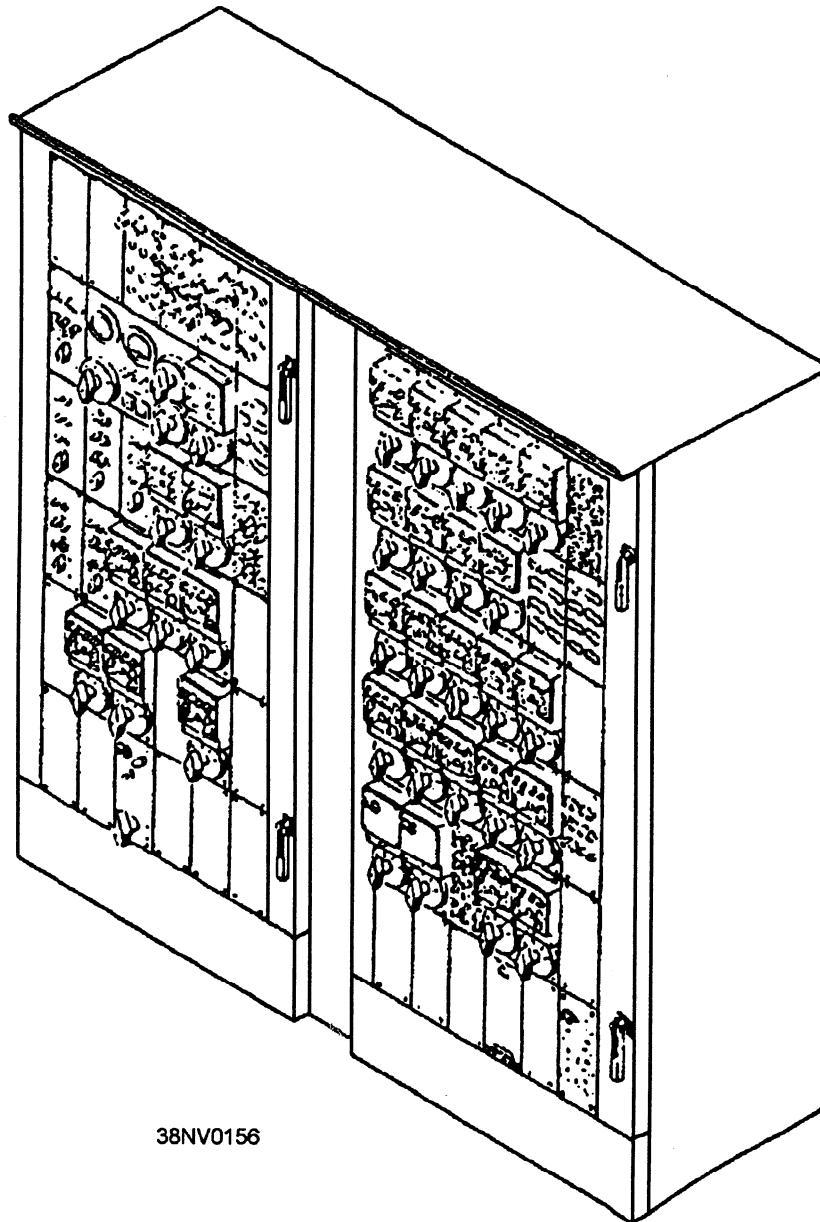
Figure 13-28.—Analog switchboard.

13-35

DOOR ASSEMBLY PANEL ASSEMBLIES MODULE CONNECTORS BACK SECTION MODULES (RIGHT AND LEFT SIDES) TERMINAL BOARDS CONNECTOR MODULE ASSEMBLY
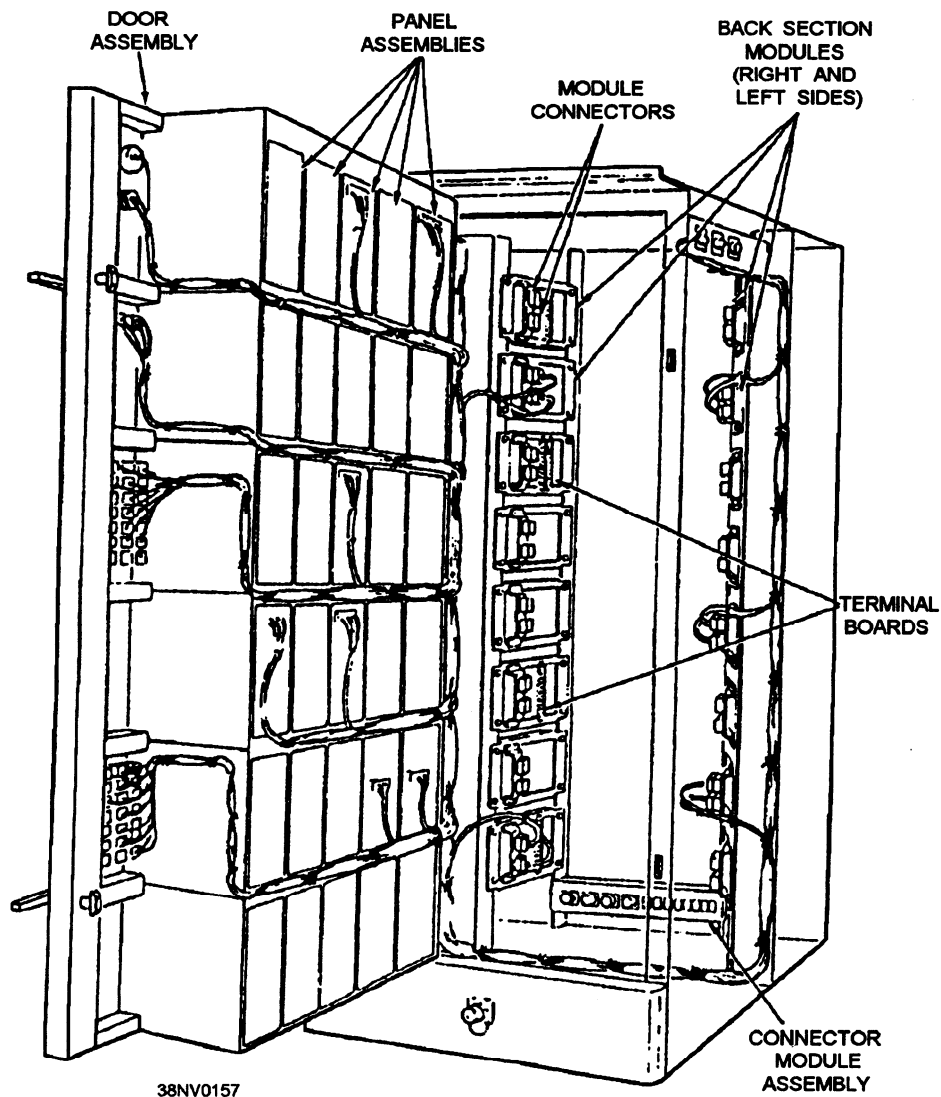
38NV0157

Figure 13-29.—Analog switchboard section, door open.

Ship's cables enter the switchboard through the rear cabinet and connect to the front of the module terminal boards (figure 13-29). From the panel assemblies, wiring is routed to the backside of the terminal boards on the modules via plug connectors. Wiring between switchboard sections is routed via inter-section connectors.

The following panel assemblies are found on analog switchboards. Individual analog switchboard layouts and configurations will vary between ship classes.

Indicator Panel Assembly

The indicator panel assembly (figure 13-30) provides a visual indication of the active power being supplied to the switchboard. The panel assembly contains up to 10 indicators, all of which are mounted on the front panel.

ETFC0160
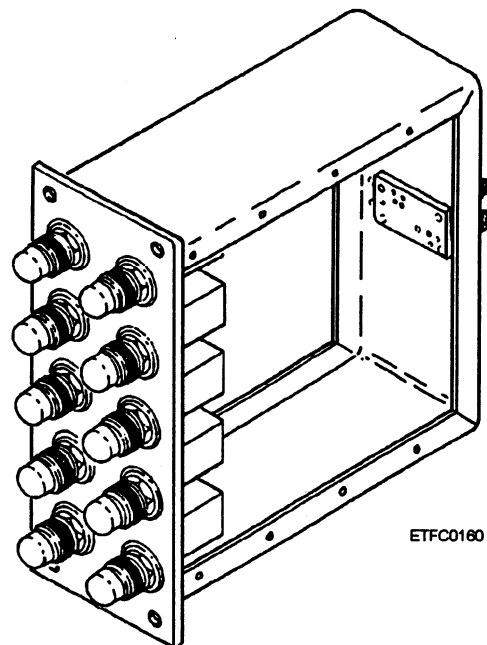
Figure 13-30.—Indicator panel assembly.
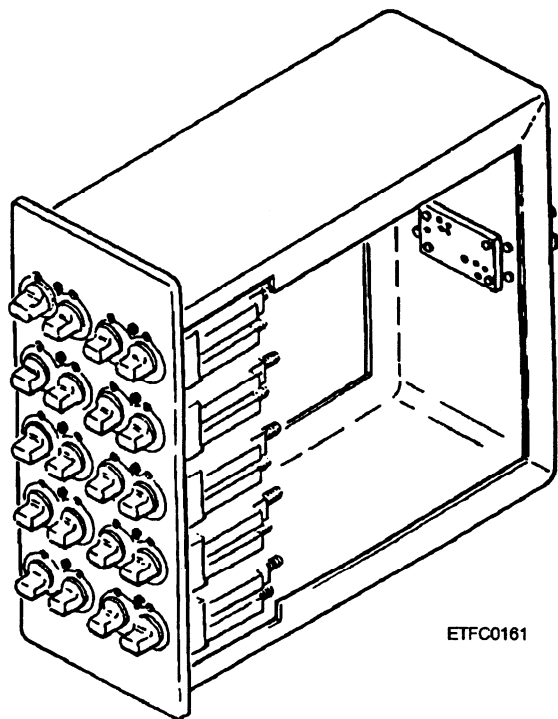
13-36

Figure 13-31.—Fuse panel assembly.

Fuse Panel Assembly

The fuse panel assembly (figure 13-31) contains overflow fuses for circuits located in an associated panel. Each panel may contain up to 10 dual indicator-type fuseholders.

Fuse Tinter Panel Assembly

The fuse tester panel (figure 13-32) functions in the same manner as the Mk 70 DFCS fuse tester panel.
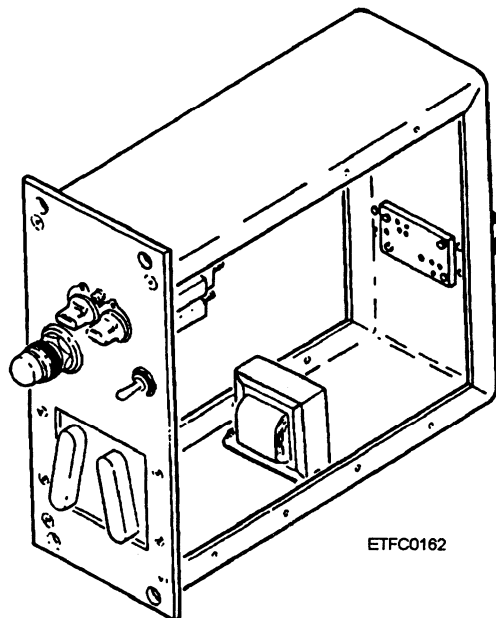

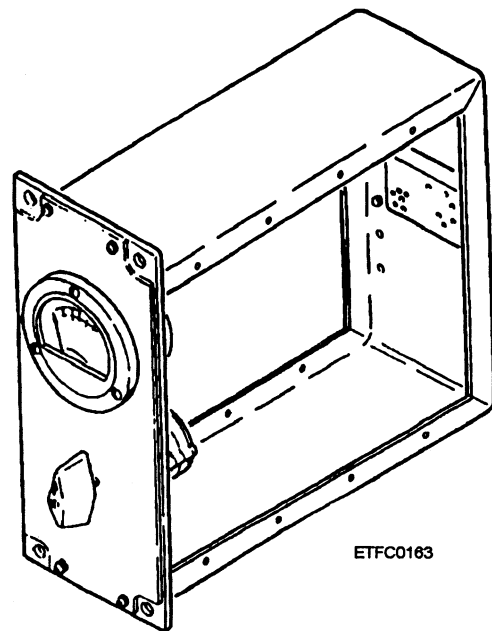Figure 13-32.—Fuse tester assembly (analog switchboard).

Figure 13-33.—Meter panel assembly.

Meter Panel Assembly

Two meter panels (figure 13-33) are used: one panel type monitors 60-Hz and 400-Hz power buses and the other monitors de buses. The panels contain an ac or de meter and a rotary snap switch. The snap switch enables voltage measurements to be performed on the selected power bus.

Flasher Panel Assembly

The flasher panel (figure 13-34) produces pulsating (ON/OFF/ON and so forth) potentials to activate
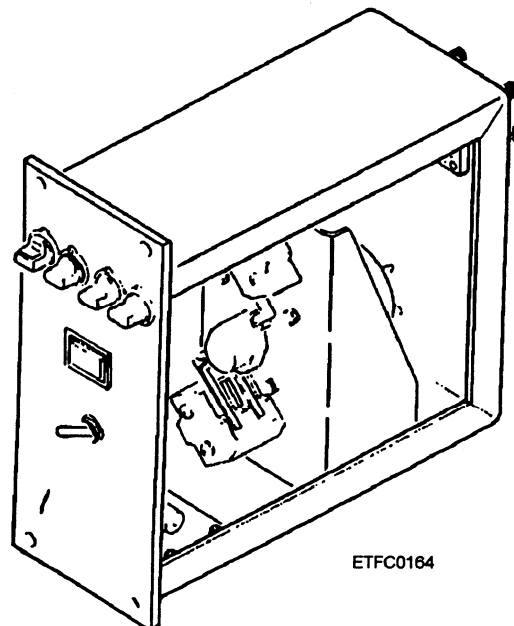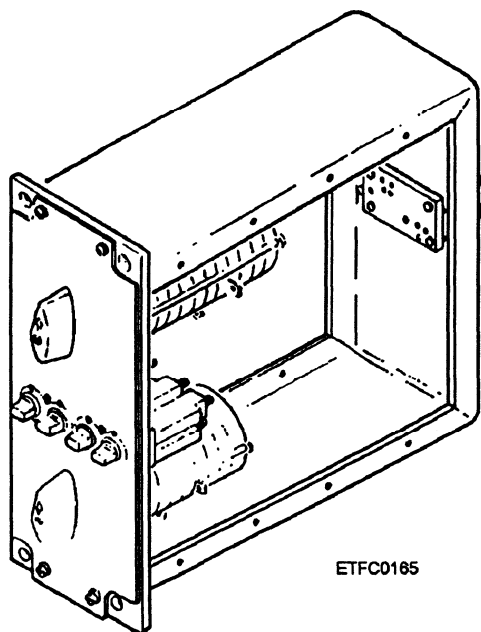

Figure 13-34.—Flasher panel assembly.

Figure 13-35.—Snap switch panel assembly.

flashing system indicators when a warning or emergency condition occurs. Motor-driven dual-cam and three-cam activated switches open and close control or status signal circuits to provide the flashing effect on indicator lamps.

Snap Switch Panel Assembly

The snap switch panel assembly (figure 13-35) provides manual control of switchboard power buses. An individual panel mat contains either one or two snap switches.

The snap switch (figure 13-36) is a device that opens or closes a circuit with a quick motion. Rotary snap switches are used extensively in the distribution
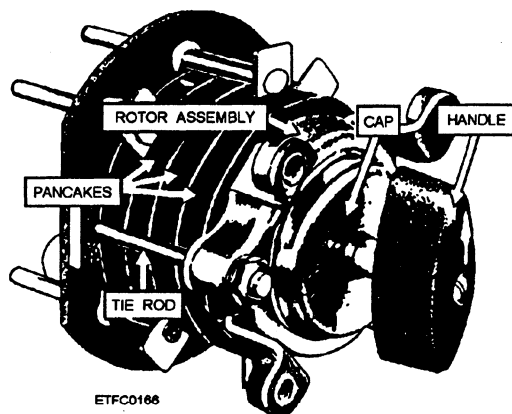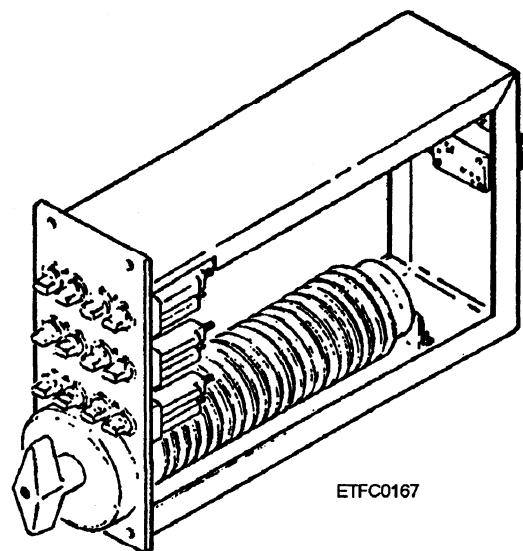

Figure 13-36.—Snap switch.

Figure 13-37.—Manually operated JR switch panel assembly.

sections of switchboards to connect the shipboard power supplies to the various switchboard power buses.

Manually Operated JR Switch Panel Assembly

The manually operated JR switch panel assembly (figure 13-37) provides manual switching and action cutout (ACO) functions. The manually operated JR switch panel assembly uses either a 2JR or 4JR switch. Both switch types are similar in construction and differ only in the electrical application because of switching action. A JR switch as shown in figure 13-38 is made up of a variable number of waferlike sections. As the switch is manually positioned, one or more moveable contacts are positioned to each switch position on the wafer. The contacts may connect (bridge) two or more contacts on each wafer effectively opening or closing circuit paths as required to configure the system for normal or alternate operation.

Remotely Operated JR Switch Panel Assembly

The remotely operated JR switch, panel (figure 13-39) provides remote and manual control of signal routing and ACO switching. The automatic junction rotary (AJR) switches used in these assemblies are driven by a motor and gear train servo system. The automatic switches allow control of switching functions from remote stations. Analog switchboards used with combat direction systems use control signals provided by the multiplexing data converter to activate the switches and provide status signals back to the converter to indicate switch position to the system.
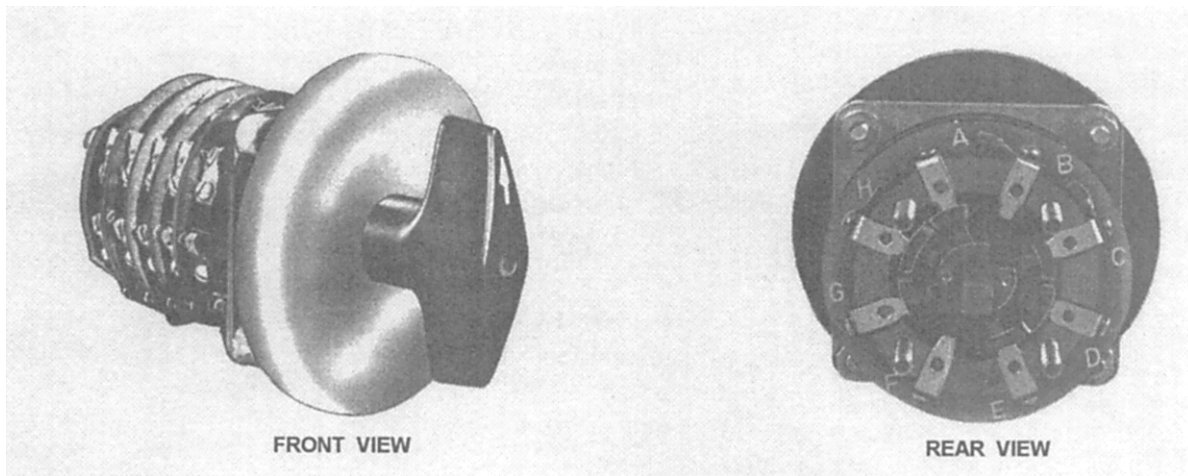
Figure 13-38.—JR switch (type 4).

Each panel contains a REMOTE-MANUAL toggle switch. The servo system controls the position of the AJR switch when the toggle switch is in the REMOTE position. The toggle switch must be placed in MANUAL to allow personnel to rotate the switch.

Linear Movement Switches

In newer switchboards and upgrades to older switchboards, the rotary-type JR and AJR switches have been replaced by linear movement switches with the same electrical configurations as the JR switches. We covered linear movement switch panel assemblies in the Mk 70 DFCS.
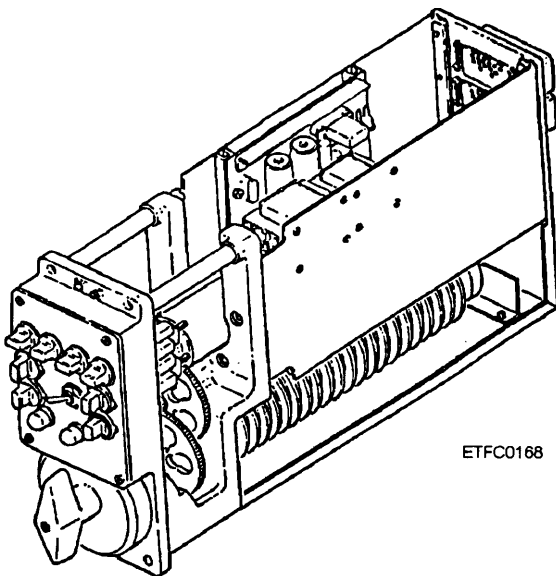

ETFC0168

Figure 13-39.—Remotely operated JR switch panel assembly.

END-AROUND-TEST (EAT)

One of the functions provided by both analog and digital switchboards is the end-around-test (EAT). When switches are in the EAT position, switchboards take the output of a device and feed it back to the same or similar device as input data. For instance, a control signal generated by a device such as the KCMX can be routed end-around as a status signal input. The output of a digital-to-synchro (D/S) converter can be fed end-around to a synchro-to-digital (S/D) converter or the output channel of a computer can be end-around as an input channel for the same computer. EAT allows for offline testing and verification of the operability of digital and analog interfaces, both within the CDS and external to the CDS.

SUMMARY—DATA CONVERSION DEVICES AND SWITCHBOARDS

This chapter has introduced you to analog-to-digital (A/D), digital-to-analog (D/A), and digital-to-digital (D/D) conversion methods and some typical conversion devices. You were also introduced to data switchboards used in system configuration. The following information summarizes important points you should have learned.

FUNDAMENTALS OF DATA CONVERSION— The digital equipment that composes the combat direction system (CDS) uses information in analog form. To use this information, the analog signals must first be converted to digital signals. The amplitude, frequency, or phase of an analog signal may represent a value within a given set of limits (minimum

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limit to maximum limit). Binary codes of ONES and ZEROS are used to represent digital values. Each bit position in a binary number represents a portion of the overall quantity being represented. The summation of the values of the set bits (ONES) determines the value to be represented.

ANALOG-TO-DIGITAL (A/D) AND DIGITAL-TO-ANALOG (D/A) CONVERSIONS— The analog-to-digital conversion process can be divided into three operations: sampling, quantization, and encoding.

ANALOG AND DIGITAL QUANTITIES— An analog signal is sampled or tested repeatedly over a period of time to determine the characteristic that contains the analog quantity. The sampled analog value is converted to the nearest binary value or quantity. The binary value is then encoded into a code acceptable to the digital equipments that use the data. Standardized binary words called BAMs (binary angular measurement) are used to transmit angular, range, and height values between digital equipments in shipboard combat direction systems. Other coding systems such as Gray code or binary-coded decimal (BCD) are also used to transmit converted values.

ANALOG-TO-DIGITAL CONVERTERS— An analog-to-digital converter is a device that receives an analog signal and converts it to a digital (binary) quantity with a given accuracy and resolution.

SYNCHROS— One of the most common analog shipboard signals indicating angular position that requires conversion to binary is the 3-phase or 5-wire synchro signal. Synchro is the name given to a variety of rotary, electromechanical, position-sensing devices. A synchro system is made up of a combination of a synchro transmitter and one or more synchro receivers. There are two major classifications of synchro systems: torque systems and control systems. Most shipboard synchro systems operate on a supply or reference voltage of 115 vac at a frequency of 60 or 400 Hz.

SYNCHRO ACCURACY— The accuracy of data transmitted by synchros is improved by using a multispeed synchro system such as a dual-speed system. A dual-speed synchro system uses two synchro transmissions, with a common reference voltage, called the coarse and fine transmissions. The coarse and fine transmissions are converted separately and the results are then combined into one BAM word.

SYNCHRO SIGNAL CONVERSION— Two methods are currently in use to convert synchro signals to digital (BAM) words: the sector method and the octant method.

SECTOR METHOD— The sector method first determines the 60-degree sector angle in which the rotor is positioned using the stator voltages. When the sector has been determined, two of the three stator voltages are sampled to determine the ratio angle within the sector. The sector angle and the ratio angle are then summed to determine the binary angle of the rotor position in BAMs.

OCTANT METHOD— The octant method first determines the 45-degree octant by converting the synchro signal into two sine and cosine voltages. The remaining angle within the octant is determined by a process of successive approximations.

THE DIGITAL-TO-ANALOG CONVERTER CV-2517B/UYK— The CV-2517B/UYK DAC is a multipurpose digital-to-analog converter. It is capable of accepting parallel digital data words (BAMs) and converting them into linear, scalar, or synchro output signals. Each DAC is divided into two channels, designated channels A and B. Each channel can output two linear voltages, a sine/cosine scalar signal, or a single-speed synchro signal.

SHIPBOARD DIGITAL/ANALOG SYSTEM INTERFACES— Shipboard digital/analog system interfaces permit nominally independent shipboard systems or subsystems to communicate or interface with the combat direction system.

MULTIPLEXING DATA CONVERTERS— Multiplexing data converters are computer-controlled multipurpose devices that operate between one or more digital computers and a variety of control, status, digital and analog devices located in remote shipboard subsystems.

KEYSET CENTRAL MULTIPLEXER (KCMX)—The KCMX provides the means for exchanging data, control, and status information between either one of two computers and a variety of I/O devices. The KCMX duplexer allows two computers to alternately control operation of the KCMX. Three external function (EF) commands are used to control the duplexer operation: REQUEST CONTROL, RELEASE LOCAL, and RELEASE REMOTE. The KCMX can operate in one of seven modes, as specified by the controlling computer: NEUTRAL, DUPLEX, RDUC (receive data from unit computer), TDUC (transmit data to unit computer), TDUC and RDUC, INTERRUPT, and KEYSET ERROR.

KCMX INPUT AND OUTPUT— The KCMX can receive ready digital (RD) data from up to eight radar azimuth converters (RACs). The ENTER signal indicates that the ready digital (RD) data is valid and may be sampled and sent to the controlling computer. The KCMX is capable of outputting data over four digital output channels (DOCs) and receiving data from four digital input channels (DICs). These channels can be manually set to computer (COMPUTE) or peripheral (PERIPH) formats. The KCMX can receive up to 60 status signals. The status signals' conditions (0 or 1) are inputted to the computer as two 30-bit status words. The KCMX generates control signals based on individual bits set in two control words received from the controlling computer.

KCMX CONVERSIONS— The KCMX can accept and convert inputs from up to 323-wire synchros using 12 reference voltages. Two separate conversions are performed for each input, one for the fine speed and one for the coarse speed. When converting single-speed synchro inputs, both conversions are performed. However, the fine conversion is ignored and the bits that apply to the fine conversion in the BAM word are zeroed.

SWITCHBOARDS— Switchboards are used to interconnect a ship's systems. There are two major types of switchboards: digital and analog.

DIGITAL SWITCHBOARDS— Digital switchboards primarily interconnect digital devices. There are two types of digital switchboards: manual switchboards and remotely controlled switchboards.

MANUAL SWITCHBOARDS— Manual switchboards are made up of variable configurations of manually operated three-position and five-position switches.

REMOTELY CONTROLLED SWITCHBOARDS— Remotely controlled switchboard configuration changes are accomplished from one of two computer switching control panels (CSCPs). The CSCP generates control signals to position the linear slide switches and receives status signals from the switches to indicate current switch position.

DIGITAL FIRE CONTROL SWITCHBOARD (DFCS)— The digital fire control switchboard (DFCS) performs data routing, power monitoring, action cutout (ACO) switching, and digital switching.

SHIP, SWITCHBOARD, AND CSCP WIRING— All cables and wires used aboard a ship are labeled with a specific code. Specific codes are used to identify ship's wiring, switchboard wiring, and CSCP wiring. These codes are found on metal or plastic labels on each end of the cable.

ANALOG SWITCHBOARDS— Analog switchboards receive control signals from the multiplexing data converter to position the automatic junction rotary (AJR) switches and provide status signals to indicate switch status.

END-AROUND-TEST (EAT)— One of the functions provided by both analog and digital switchboards is the end-around-test (EAT). When switches are set to the EAT position, the switchboard routes the output of a device back to the same or similar device as input data.